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Aeronautical Engineering
A Continuing Bibliography with Indexes

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NASA SP-7037(224)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 224)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in February 1988 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 447 reports, journal articles and other documents originally announced in February 1988 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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Category 10	**Astronautics** Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.	**108**
Category 11	**Chemistry and Materials** Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.	**108**

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Category 14 Life Sciences N.A.
Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 119
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 122
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

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Category 18 Space Sciences N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

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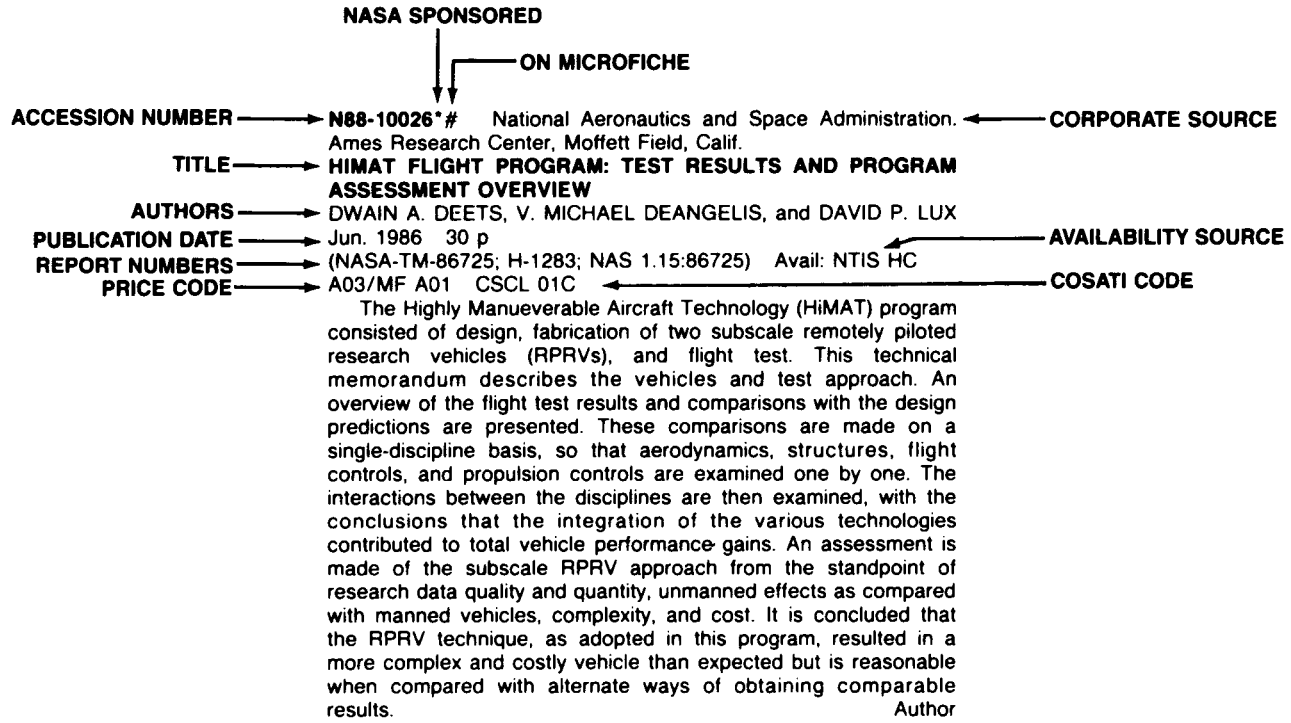
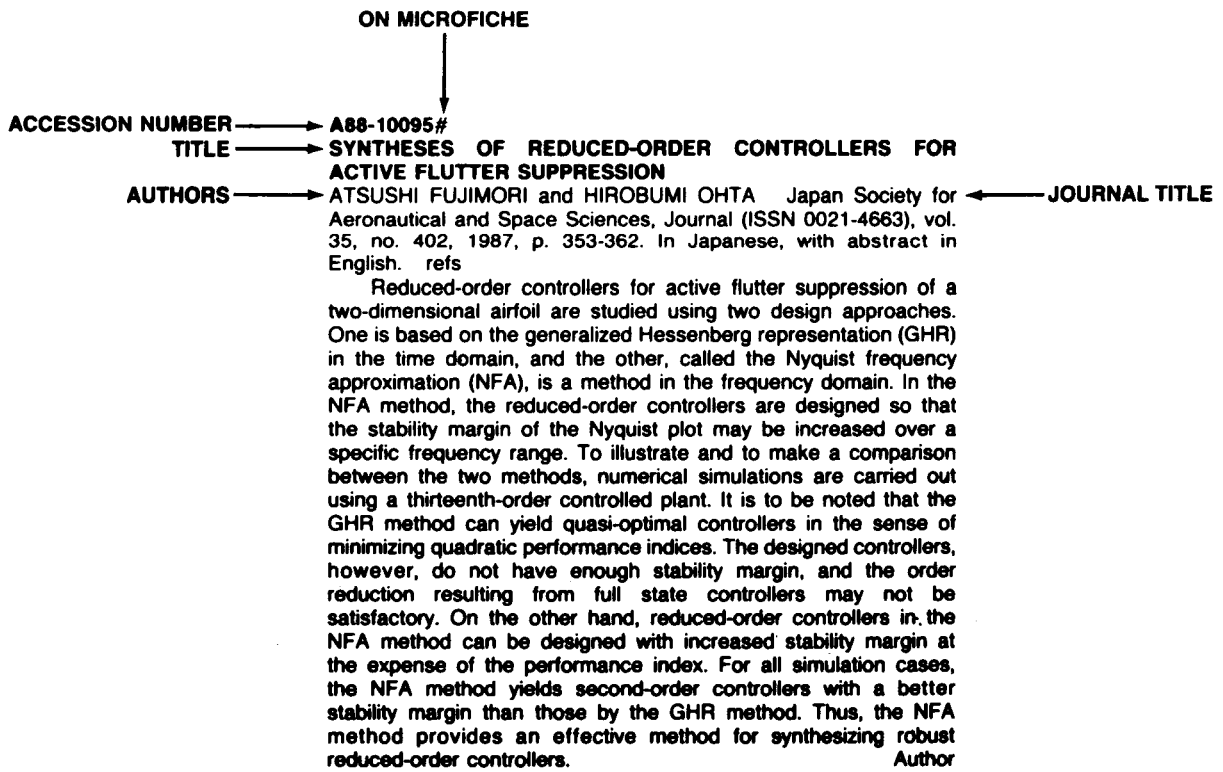
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 224)

MARCH 1988

01

AERONAUTICS (GENERAL)

A88-14050
AIRSHIPS FACE A MILITARY FUTURE
MICK HAMER New Scientist (ISSN 0028-6664), vol. 115, Sept. 24, 1987, p. 38-40.

The Sentinel 5000 is a large (50,000 cu m) semirigid airship which will begin USN AWACS operations trials in 1990, equipped with a massive surveillance radar installed within its envelope. The lift capacity of the Sentinel 5000 will be such as to enable a hypothetical civilian version to carry 120-150 passengers. The development of this helium lift gas airship has been prompted by the need for naval task force AWACS coverage for periods of more than two days. Sentinel 5000 has a mission endurance of 55 hours. If the trials are successful, between 40 and 50 airships of this type may be ordered by the USN. O.C.

A88-14273#
DEFENSE SUPPRESSION TECHNOLOGY ALTERNATIVES FOR FUTURE GENERATION AIRCRAFT
RICHARD A. NIKSCH (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 7 p.
(AIAA PAPER 87-2925)

The Defense Suppression Study was conducted to assess advanced technology alternatives as they applied to new conceptual designs of manned and unmanned air vehicles performing the year-2000 Defense Suppression role. The study identified the future defense suppression needs, through scenario/threat definitions, provided potential answers through conceptual manned/unmanned air vehicles, evaluated the concepts as they related to the combat potential of the attack forces, and made critical technology assessments and recommendations of what needs to be done to meet future requirements. Four manned and several unmanned vehicles were designed and analyzed. Additionally ten advanced weapons were evaluated, many potential advanced avionics were determined, and eight tactics methods were contrived and evaluated, using the new technology capabilities. Author

A88-14275#
TECHNICAL THRESHOLDS FOR REVITALIZING GENERAL AVIATION
E. F. KRAUS (Cessna Aircraft Co., Wichita, KS) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 12 p. refs
(AIAA PAPER 87-2933)

The decline in general aviation sales in the 1980's is shown to be the result of numerous interdependent factors in the overall aviation environment. While lower costs and improved features and performance would positively affect sales, a review of market conditions indicates that the threshold for accomplishing a significant market turnaround through cost and performance improvements alone is beyond the near term application of advanced aerodynamics, propulsion and materials technologies. While such improvements remain essential for the success of new designs, they are shown to play a secondary role in the marketplace to technologies that lower the real barriers to a larger market for personally flown aircraft. Although market variables do not provide the basis for rigorous proof, appropriate technologies for market expansion are indicated. Author

A88-14282#
SYSTEM DESIGN AND EFFECTIVENESS - IMPROVING BUILT-IN-TEST DESIGNS
TRACY H. JACKSON (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 5 p. refs
(AIAA PAPER 87-2945)

This paper describes the background work used to determine causes of Cannot Duplicate (CND) and Bench Checked, Serviceable (BCS) action. A new figure of merit, Expended Maintenance Importance Ratio is discussed. Techniques for eliminating CND and BCS actions through off-aircraft techniques are discussed, using data from in-depth studies. Current efforts to identify on aircraft improvements in flight control systems are discussed. Development efforts discussed include: (1) a built-in-test effectiveness model used to unambiguously quantify diagnostic results; (2) near real time diagnostic systems for use on board aircraft; and (3) suggested on aircraft measurements required to eliminate CND and BCS diagnostic results. Author

A88-14283#
THE CHANGING WORLD OF FLIGHT TESTING
ORVILLE WRIGHT, JR. (IBM, Federal Systems Div., Owego, NY) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 4 p. refs
(AIAA PAPER 87-2948)

The paper discusses the evolution of flight testing from the first military flight demonstration in 1908 to the present day evaluations. It highlights the reasons that are causing the changes in testing methodology: enormous costs of weapon systems, advancing technology, long development cycle, and user impatience with unreliable equipment. In addition, it projects the future direction in view of the emerging role of avionics systems, simulation, joint test teams and software flexibility. Author

A88-14301
AIRSHIP DESIGN AND OPERATION - PRESENT AND FUTURE; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, LONDON, ENGLAND, NOV. 18, 19, 1986. VOLUMES 1 & 2
Conference sponsored by the Royal Aeronautical Society and Airship Association. London, Royal Aeronautical Society, 1986, p. Vol. 1, 99 p.; vol. 2, 261 p. 360 p. For individual items see A88-14302 to A88-14317.

The present conference on the state of the art in LTA craft development discusses design trends observable in recent airships, emerging civil applications for airships, the development of a large nonrigid airship, the design and construction of the UM10 ultralight nonrigid airship, military and civilian applications for tethered aerostats, the static, dynamic and powered-static components of airship lift, and test flight results for the 'Cyclo-crane' proof-of-concept airship. Also discussed are military applications for airships, long endurance airship design challenges, the status

of airship flight dynamics research, RPV-carrying airships, the passenger potential of airships, a toroidal balloon concept, and the case for a solar-powered airship. O.C.

A88-14302
RECENT AIRSHIP DESIGNS AND TODAY'S ACHIEVEMENTS
A. W. L. NAYLER (Royal Aeronautical Society, London, England) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 1 . London, Royal Aeronautical Society, 1986, p. 2.1 to 2.10. refs

An evaluation is made of advancements in airship design since 1971, encompassing rigid airships for heavy-lift requirements as well as the smaller, more numerous nonrigid airships developed for surveillance, forestry, and advertising applications. Britain, the USA, Canada, Mexico, Germany, the USSR, Australia, New Zealand, and Japan all have active private or military airship development programs. The US and French navies have already undertaken trials to ascertain the applicability of nonrigid airships to task force surveillance. O.C.

A88-14303
CIVIL APPLICATION FOR AIRSHIPS BY AIRSHIP INDUSTRIES
GEORGE SPYROU (Airship Industries /UK/, Ltd., London, England) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 1 . London, Royal Aeronautical Society, 1986, p. 3.1 to 3.8.

A total of nine airships have been constructed by the presently discussed British company over the last 15 years. Successful civil applications have been found for these vehicles in advertising/promotion, aerial TV/film/photographic coverage of outdoor events, aerial surveillance, geophysical and hydrographic surveying, and passenger/sightseeing tours. The company has recently entered into a partnership with a major U.S. defense electronics manufacturer to develop surveillance airships for the USN, designated the 'Sentinel 5000'. O.C.

A88-14304
THE DEVELOPMENT OF THE LARGE NON RIGID AIRSHIP
J. R. MUNK (Airship Industries /UK/, Ltd., London, England) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 1 . London, Royal Aeronautical Society, 1986, p. 4.1 to 4.7.

A partnership between a British airship manufacturer and a U.S. defense electronics manufacturer has been contracted by the USN to develop a large nonrigid AEW airship for use in fleet radar surveillance. The radar antenna is large and mounted on a quadrupod structure above the gondola. The hull form used is inherently resistant to buckling under load, and employs high tear strength/low weight fabric. Advanced composites are used in the tail fins, nose cone battens and strakes of the hull. Attention is given to the cruise propulsion system's drivetrain configuration and the fly-by-light control system. O.C.

A88-14308
MILITARY AND CIVIL APPLICATIONS FOR AIRSHIPS
DAVID B. BAILEY (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 11.1 to 11.68. refs

This comprehensive treatment of LTA vehicle development history, current status, and future trends, encompasses existing military and commercial development programs on a country-by-country basis, the design and operational lessons learned from the classic generation of rigid (Akron, Graf Zeppelin) and nonrigid (ZPG-2, ZPG-3) airships, and the results of numerous experiments with exotic LTA vehicle concepts, such as hybrid-lift semibuoyant airships. Attention is given to tethered aerostats, the operational hazards and capabilities of the USN's World War II escort blimps, and the general construction principles of each airship type. O.C.

A88-14309
THE DESIGN CHALLENGE OF A LONG ENDURANCE AIRSHIP
R. H. HILLSDON (Airship Industries /UK/, Ltd., London, England) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 12.1 to 12.12.

The U.S. Navy Airship Program ('NASP') is concerned with the development of airships for a long-endurance oceanic surveillance role. An account is given of the engineering tradeoff study determinations that entrants into the NASP design competition will have to make, in light of numerous constraints and criteria that are either intrinsic to long mission duration airship operations, or extrinsically introduced by surveillance radar accomodation and other such specific, mission-related requirements. Attention is given to propulsion system options, ballonet configuration factors, and reliability and maintainability issues associated with the stipulated 720-hour mission length. O.C.

A88-14312
RPV CARRYING AIRSHIPS
B. SHAW (Ministry of Defence Royal Navy, London, England) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 15.1 to 15.6.

A technological, operational, and economic feasibility evaluation is presented for the use of airships as platforms for the launch, monitoring, control, and recovery of RPVs outfitted with sensors for sea and air attack-warning reconnaissance. It is noted that the size and speed disadvantages of airships in high intensity warfare scenarios can be compensated for by the speed, agility, and indetectability of RPVs equipped with highly miniaturized, but powerful, radar and IR sensors. This use of airships and RPVs would not only be less expensive than current alternatives, but would free higher-valued aircraft for more pressing tasks. O.C.

A88-14313
A DEMONSTRATION OF THE USE OF AN AIRSHIP FOR TOWING A REFLECTIVE SPHERE AT MEDIUM ALTITUDES
K. N. READER (Royal Signals and Radar Establishment, Malvern, England) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 16.1 to 16.10.

The suitability and economy of two different helicopters, a jet aircraft, and an airship are presently considered in the role of towing vehicles for a radar range-performance calibration reflecting target sphere of 3-ft diameter. The VTOL and hover capabilities of the airship render its performance comparable to that of the helicopters, with far lower costs than either the helicopters or the jet aircraft. An agreement of better than 20 percent is obtained between measured and predicted figures. O.C.

A88-14371
THE EXPERIMENTAL AIRCRAFT PROGRAMME
JOHN VINCENT (British Aerospace, PLC, Military Aircraft Div., Weybridge, England) SAE, Aerospace Vehicle Conference, Washington, DC, June 8-10, 1987. 17 p.
(SAE PAPER 871347)

The Experimental Aircraft Program is a demonstrator aircraft program involving the equipment industries of the UK, the FRG and Italy. The program part funded by UK MoD(PE) was aimed at developing those technologies necessary for any future advance fighter aircraft. These included an advanced aerodynamic configuration requiring full authority digital computer-based flight controls. A utilities and systems management system integrated by data bus with avionics provides the pilot with a modern electric cockpit. Advanced materials are used in primary and secondary

structure. The timescale from contract signature to first flight was three years. Flight development is continuing. Author

A88-14878#
AERONAUTICAL DEVELOPMENTS FOR THE 21ST CENTURY
JOHN M. SWIHART (Boeing Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 13-16, 1987. 48 p. refs
(AIAA PAPER 87-3052)

A comprehensive projection is made of commercial aviation market possibilities for prospective technology development trends in subsonic, supersonic, and hypersonic aircraft designs. Attention is given to the advantages in propulsion efficiency and supersonic airframe temperature control that may be obtained through the use of such exotic fuels as liquid hydrogen and methane (especially in the hypersonic regime), as well as to the range extension and takeoff gross weight reduction that can be obtained from the incorporation of active boundary layer control in both subsonic and supersonic aircraft. SST boundary layer control is noted to offer the further advantages of reduced skin aerodynamic friction-induced heat and sonic boom overpressure reduction. O.C.

A88-14879
AIRCRAFT MAINTENANCE AND PRODUCTION TECHNOLOGY; SYMPOSIUM, TECHNISCHE HOGESCHOOL DELFT, NETHERLANDS, APR. 25, 1986, PROCEEDINGS [ONDERHOUDS- EN PRODUCTIETECHNIEKEN IN DE LUCHTVAART; SYMPOSIUM, TECHNISCHE HOGESCHOOL DELFT, NETHERLANDS, APR. 25, 1986, PROCEEDINGS]
Delft, Netherlands, Vliegtuigbouwkundige Studievereniging, 1986, 87 p. In Dutch. No individual items are abstracted in this volume.

State-of-the-art manufacturing and maintenance procedures for commercial transport aircraft are surveyed, with a focus on developments in the Netherlands. Topics addressed include the technological history of the aircraft industry (emphasizing the trend toward greater automation), the use of composite materials in aircraft structures, the production and repair of undercarriages, and the automated production of cable harnesses. Consideration is given to methods for improving aircraft maintainability, motor maintenance, and the maintenance of aircraft exteriors. Extensive diagrams, drawings, graphs, photographs, and tables of numerical data are provided. T.K.

A88-15116
THE ANALYSIS OF AIRCRAFT COMPONENT FAILURES
A. JONES and C. J. PEEL (Royal Aircraft Establishment, Farnborough, England) IN: Analyzing failures: The problems and the solutions . Metals Park, OH, ASM International, 1986, p. 201-208.

This paper outlines the developments in both understanding the failures and the practical techniques that have been applied in their interpretation. Previous failures are reviewed, and the relative importance of the various failure modes encountered indicated, emphasizing the dominant role of fatigue of metal structures and the improvements that have occurred, particularly with corrosion related problems. Improved techniques for the quantitative analysis of fatigue failures are explained and illustrated, including combined fractographic and fracture mechanics analyses. Author

A88-15175
TILTING AT NEW AVIATION MARKETS
HELEN GAVAGHAN New Scientist (ISSN 0028-6664), vol. 116, Oct. 1, 1987, p. 38-43.

A new aircraft called a tiltrotor has been developed which takes off as a helicopter; the rotors on the wing then tilt through 90 deg so that the aircraft can fly as a conventional turboprop aircraft. The tiltrotor combines a helicopter's ability to take off and land from confined spaces with the fuel efficiency and speed of a turboprop for the flight between destinations. For the armed forces, an aircraft that has the versatility and speed of a fixed-wing aircraft and yet can land in a battle zone which has no prepared landing surface, has many advantages. For civil operation, such aircraft operating between city centers, could relieve the growing tension at airports. The European concept, known as Eurofar, is described. The Osprey, the direct descendent of an experimental tiltrotor (XV3) is scheduled to fly for the first time in June of 1988. K.K.

A88-16345#
APPLICATION OF 'PADDING OFFSET' IN AIRCRAFT ASSEMBLY
FANGLIN XIE (Shanxi Aircraft Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, June 1987, p. B321-B325. In Chinese, with abstract in English.

In aircraft assembly, clearance often occurs between assembly components caused by random and systematic errors. This article discusses the theoretic basis and technological specification of a padding treatment for assembly clearance. Also proposed is the proper application of padding offset method, so as to simplify the complicated coordination procedure for the purpose of reducing cost and improving product quality. Author

A88-16376
AEROSPACEPLANE - NASA'S FLAME REKINDLED
JULIAN MOXON Flight International (ISSN 0015-3710), vol. 132, Oct. 10, 1987, p. 31, 32.

The NASA/USAF joint National Aerospaceplane ('NASP') program has as its goal the creation of a Mach 25-capable, SSTO vehicle that will also be able to sustain endoatmospheric hypersonic cruise for passenger-carrying and reconnaissance missions. The testing of the integration of numerous state-of-the-art technologies involved in NASP has generated the further requirement for the creation of the X-30 test vehicle. Attention is presently given to the programmatic consequentiality of the development of an operational scramjet powerplant that can achieve sustained operation in the X-30. O.C.

A88-16651
LIGHTER THAN AIR INTERNATIONAL CONFERENCE, VANCOUVER, CANADA, SEPT. 18, 19, 1986, PROCEEDINGS
WILLIAM A. GAJDA, ED. Conference sponsored by Transport Canada, UNIDO, ICAO, et al. Edmonton, Canada, Lighter Than Air International, 1986, 264 p. For individual items see A88-16652 to A88-16663.

The present conference on the development status of LTA vehicles discusses the 'Dynairship' lifting body vehicle, the 'Cyclocrane' LTA vehicle, the elimination of negative airship characteristics through innovative design, the BUZ rigid-pressure airship, LTA-based aerial logging, the status of the GZ-22 airship program, and the 'Helitruck' rigid airship. Also considered are the 'Hystar' aerodyne airship, the development of the Canadian north using an LTA network, maritime missions using an integrated LTA role, the development of naval airships, military and civilian applications for tethered aerostats, and the implications of technological advancements in LTA systems for developing countries. O.C.

A88-16652
THE DYNAIRSHIP - A LIFTING BODY AIRSHIP FOR CARGO
WILLIAM MCE. MILLER, JR. (Aereon Corp., Princeton, NJ) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 7-20.

The deurbanization of populations and commerce, the rise of dispersed light industries, and the high cost of surface transport infrastructure in the industrialized countries, all converge to create the need for an 'aerial truck' having high payload volume and weight capacity, adaptability, simplicity, and fuel economy. The difficulty and cost of conventional land transportation infrastructure development in the Third World also presents valuable opportunities for aircraft with such capabilities. Attention is presently given to the design and capabilities of a delta-planform hybrid-lift airship that addresses these transportation requirements. O.C.

A88-16653
THE CYCLO-CRANE - AN LTA HYBRID SUCCESS STORY
JOHN R. AIKMAN (Aerolift, Inc., Tillamook, OR) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 21-27.

A development history and current status evaluation are presented for the 'Cyclo-Crane' hybrid-lift vehicle, a piloted test model of which was flown last year. Attention is given to this craft's operational and economic advantages over alternative forms of air transportation, its potential civil and military applications, and its commercial prospects. The pilot controls of the Cyclo-Crane are virtually identical to those of a helicopter; the craft operates without need for ballast, as conventional airships do. Only about 25 percent of the rotor lift power of a conventional helicopter is required for a comparable load. O.C.

A88-16654
ELIMINATION OF AIRSHIP NEGATIVE FEATURES THROUGH INNOVATION AND DESIGN
W. E. WRIGHT (Arrohawk Developments, Inc., Medley, Canada) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 83-92.

The status of the 'Arrowhawk' hybrid LTA vehicle design development effort, which has been in existence for six years, is discussed with attention to this configuration's novel integration of numerous features and capabilities generally associated with dirigibles, helicopters, and conventional fixed-wing aircraft. The Arrowhawk vehicle employs a ridid composite shell to define a helium lifting-gas volume whose external contours also define an aerodynamically functional lifting body. The craft is applicable to police patrols, coastal surveillance, search-and-rescue, and forestry surveillance. O.C.

A88-16655
AERIAL LOGGING
G. V. WELLBURN (Forest Engineering Research Institute of Canada, Vancouver) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 101-105. refs

The British Columbia forest industry requires a flight vehicle suitable for logging operations whose operational characteristics are comparable to those of a large cargo helicopter but whose economies of ownership and operation are significantly better. The size of the market for such aircraft depends on their cost-competitiveness relative to conventional cable logging under difficult terrain and weather conditions. Attention is given to the suitability of the 'Cyclo-Crane' LTA vehicle concept for such an application. O.C.

A88-16656
THE DEVELOPMENT OF THE GZ-22 AIRSHIP PROGRAM
RONALD G. E. BROWNING (Goodyear Aerospace Corp., Akron, OH) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 107-112.

While the GZ-22 airship was initially conceived with the requirements of advertising blimps in mind, innovative features incorporated in the design of its car, flight controls, avionics, instrumentation, and propulsion system render it suitable for military applications. The GZ-22 is of the same dimensions as the ZPG-3W airships built for the USN around 1960, but will be faster, more maneuverable, and more difficult to detect than earlier airships. It will stay on station 72 hours without refueling; power will be provided by a combination of gas turbine-driven generators and electric motors, which will in turn drive vectorable ducted propellers. O.C.

A88-16657
AIRSHIPS IN THE MARKET PLACE
FRED R. NEBIKER (Goodyear Aerospace Corp., Akron, OH) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 113-122.

A comprehensive evaluation is presented of the development efforts undertaken by a large U.S. nonrigid airship manufacturer over the course of several decades, even in a climate which promised no market for military airships. It is this market, however, which promises to revive in the coming years, and will require new airship designs to undertake over-the-horizon anticruise missile surveillance functions with large radar arrays in defense of USN task forces. Other foreign military services have expressed interest in airships capable of this function. O.C.

A88-16658
THE EMERGENCE OF THE RIGID AIRSHIP IN THE HELITRUCK
JUERGEN BOTHE (Helitrans, Inc., Walldorf, Federal Republic of Germany) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 123-129.

By the year 2000, more than 75 percent of all mankind will live in areas possessing less than 15 percent of the globally available ground transportation infrastructure; these 4 billion people will have to be supplied aerially with various types of cargo. This function is the mission requirement for which the presently described 'Helitruck' vehicle concept was conceived. Helitruck consists of a 40-m long, 3.2-slenderness ratio lifting body equipped with four vectorable propellers, as well as an LFC suction-supplying ducted fan. Some 40 passengers can be accomodated by the craft in VTOL, and 75 in STOL operations. O.C.

A88-16659
THE HYSTAR AERODYNE AIRSHIP
GEORGE O. NINKOVICH (Hystar Aerospace Development Corp., Vancouver, Canada) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 131-137.

The Hystar airship is a flying saucerlike LTA configuration whose circular planform and propulsion system design allow it to instantaneously turn in any direction, as well as to execute VTOL operations like a hovercraft. The aircraft is presently suggested to be applicable to aerial surveillance, geophysical surveying, agricultural spraying, fishing, and logging. Size comparisons are presented for the Hystar craft and both the conventional and 'Cyclo-Crane' LTA craft for similar payloads. O.C.

A88-16662
AN OVERVIEW OF ULITA INDUSTRIES INC.
MARK R. FORSS (Ulita Industries, Inc., Sheboygan, WI) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 217-233.

Ulita Industries was formed in 1974 for the development of Light Utility Airships (LUAs), defined as nonrigid, He-filled airships ranging in size from 15,000 to 120,000 cu ft. Attention is given to the features and development status of the sport/utility UM-10, and the larger and more sophisticated LUA-1 and LUA-2 craft. The prototype control car of the LUA-1 has been constructed, and the construction of a UM-10 prototype is planned. O.C.

A88-16663
AN INTRODUCTION TO US AIRSHIP AND THE USA-100
RAY MCIVER and JIM THEO (U.S. Airship Corp., Eugene, OR) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 239-245.

A project management organization and vehicle development status report is presented for the USA-100 airship, which is about 2/3 the size of a conventional Goodyear blimp and employs only one engine for (nonvectorable) fan propulsion. Notwithstanding

these simplifications, a useful load that is comparable to that of the larger blimp is achieved. The primary application of this small nonrigid airship is in advertising. O.C.

A88-16749*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RETOOLING CFD FOR HYPERSONIC AIRCRAFT
DOUGLAS L. DWOYER (NASA, Langley Research Center, Hampton, VA), PAUL KUTLER (NASA, Ames Research Center, Moffett Field, CA), and LOUIS A. POVINELLI (NASA, Lewis Research Center, Cleveland, OH) Aerospace America (ISSN 0740-722X), vol. 25, Oct. 1987, p. 32-35, 41.

The CFD facility requirements of hypersonic aircraft configuration design development are different from those thus far employed for reentry vehicle design, because (1) the airframe and the propulsion system must be fully integrated to achieve the desired performance; (2) the vehicle must be reusable, with minimum refurbishment requirements between flights; and (3) vehicle performance must be optimized for a wide range of Mach numbers. An evaluation is presently made of flow resolution within shock waves, transition and turbulence phenomenon tractability, chemical reaction modeling, and hypersonic boundary layer transition, with state-of-the-art CFD. O.C.

N88-11628# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
SOVIET AVIATION TECHNOLOGY'S STATE OF THE ART SU-27 FIGHTER
GONG FEI 15 Jul. 1987 12 p Transl. into ENGLISH from Conmilit (People's Republic of China), v. 1, issue 122, 1 Jan. 1987 p 61-62
(AD-A184121; FTD-ID(RS)T-0528-87) Avail: NTIS HC A03/MF A01 CSCL 01C

The SU-27 fighter makes use of avionics equipment representing the highest current level of Soviet technology and is estimated to be comparable in its overall capabilities to third generation U.S. fighters. What is attracting peoples' interest is whether or not the SU-27 is able to undertake long range interceptor missions or has been created as a medium-type fighter for loading aboard aircraft carriers. GRA

N88-12452*# United Technologies Corp., East Hartford, Conn.
A FULL POTENTIAL FLOW ANALYSIS WITH REALISTIC WAKE INFLUENCE FOR HELICOPTER ROTOR AIRLOAD PREDICTION
T. ALAN EGOLF and S. PATRICK SPARKS Washington NASA Jan. 1987 69 p
(Contract NAS2-11150)
(NASA-CR-4007; NAS 1.26:4007; R86-915999-13) Avail: NTIS HC A04/MF A01 CSCL 01B

A 3-D, quasi-steady, full potential flow solver was adapted to include realistic wake influence for the aerodynamic analysis of helicopter rotors. The method is based on a finite difference solution of the full potential equation, using an inner and outer domain procedure for the blade flowfield to accommodate wake effects. The nonlinear flow is computed in the inner domain region using a finite difference solution method. The wake is modeled by a vortex lattice using prescribed geometry techniques to allow for the inclusion of realistic rotor wakes. The key feature of the analysis is that vortices contained within the finite difference mesh (inner domain) were treated with a vortex embedding technique while the influence of the remaining portion of the wake (in the outer domain) is impressed as a boundary condition on the outer surface of the finite difference mesh. The solution procedure couples the wake influence with the inner domain solution in a consistent and efficient solution process. The method has been applied to both hover and forward flight conditions. Correlation with subsonic and transonic hover airload data is shown which demonstrates the merits of the approach. Author

N88-12453*# Florida Univ., Gainesville. Dept. of Engineering Sciences.
REDUCED COMPLEXITY STRUCTURAL MODELING FOR AUTOMATED AIRFRAME SYNTHESIS
PRABHAT HAJELA May 1987 79 p
(Contract NCA2-IR240-401)
(NASA-CR-177440; NAS 1.26:177440) Avail: NTIS HC A05/MF A01 CSCL 01B

A procedure is developed for the optimum sizing of wing structures based on representing the built-up finite element assembly of the structure by equivalent beam models. The reduced-order beam models are computationally less demanding in an optimum design environment which dictates repetitive analysis of several trial designs. The design procedure is implemented in a computer program requiring geometry and loading information to create the wing finite element model and its equivalent beam model, and providing a rapid estimate of the optimum weight obtained from a fully stressed design approach applied to the beam. The synthesis procedure is demonstrated for representative conventional-cantilever and joined wing configurations. Author

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A88-13118
27TH LANCHESTER MEMORIAL LECTURE - SCALE EFFECT IN TRANSONIC FLOW
A. B. HAINES Aeronautical Journal (ISSN 0001-9240), vol. 91, Aug.-Sept. 1987, p. 291-313. refs

A history is presented of the last 35 years' development of research in the field of the scale effect in transonic flow. Much of this research is noted to have concentrated on two-dimensional flow, whose results were then applied to the prediction of three-dimensional configuration phenomena; the assumption of scale effect constancy in such extrapolations is frequently unwarranted. It is judged that present knowledge concerning such cases as moderate aspect ratio combat aircraft wings does not allow flow prediction to the degree of accuracy desired. O.C.

A88-13119
AN ASSESSMENT OF THE USE OF LOW-ORDER PANEL METHODS FOR THE CALCULATION OF SUPERSONIC FLOWS
J. S. SMITH and D. S. WOODWARD (Royal Aircraft Establishment, Aerodynamics Dept., Farnborough, England) (NATO, AGARD, Symposium on Applications of Computational Fluid Dynamics in Aeronautics, Aix-en-Provence, France, Apr. 7-10, 1986) Aeronautical Journal (ISSN 0001-9240), vol. 91, Aug.-Sept. 1987, p. 314-320. refs

Three low-order panel methods developed for the analysis of supersonic flows have been used to make calculations for a number of test configurations, with the aim of establishing the range of problems for which this class of computational method yields adequate solutions. The programs investigated were the Woodward USSAERO/C program, the related NLRAERO program, and the British Aerospace Warton supersonic panel program. Results obtained using these programs have been evaluated against theoretical and experimental data for a number of test cases covering wing-alone, body-alone and wing-body geometries. It is concluded that low-order panel methods can provide adequate solutions for supersonic flows about wings, bodies and wing-body combinations, provided the assumptions implicit in the linearized potential flow model are not violated. Examples show that the prediction of lift and pitching moment curve slopes for quite complex configurations may be acceptable, but that the detailed pressure distributions are not always predicted satisfactorily. In particular, serious problems are encountered in calculating the flow about

wings with rounded supersonic leading edges due to the linearized flow model which is used. Author

A88-13121
A NUMERICAL MODEL FOR ANALYSIS OF THIN WINGS IN INVISCID INCOMPRESSIBLE FLOW
B. K. SINGH and B. C. BASU (Indian Institute of Technology, Kharagpur, India) Aeronautical Journal (ISSN 0001-9240), vol. 91, Aug.-Sept. 1987, p. 333-337. refs

A planar vortex sheet model for analysis of thin wings in inviscid incompressible flow is presented. In this model a network of spanwise quadratically varying semi-infinite doublet sheets is introduced which produces a continuous trailing vortex wake. The present method has been applied to wings fitted with partial span trailing edge flaps after appropriate modification to account for the flap juncture. Also, the problem of wings in sideslip is attempted by incorporating the zero load condition at the down stream wing tip. The comparison of results shows that the proposed model retains the simplicity of the vortex lattice model to a large extent while overcoming the limitations of the standard vortex lattice model regarding lattice arrangement and number. Author

A88-13265
FREE-WAKE ANALYSIS OF HELICOPTER ROTORS - A BOUNDARY ELEMENT APPROACH
B. K. BHARADVAJ and L. MORINO (Boston University, MA) IN: Betech 86; Proceedings of the Second Boundary Element Technology Conference, Cambridge, MA, June 17-19, 1986 . Southampton, England and Billerica, MA, Computational Mechanics Publications, 1986, p. 291-303. refs
(Contract DAAG29-83-K-0050)

A simple and direct BEM analysis of unsteady viscous external flow is presented which is based on the classical decomposition of Helmholtz. The vorticity evolution equation is solved using a method involving material contravariant components. Results obtained with the method for the case of the free wake of helicopter rotors in hover are found to be in good agreement with previous experimental data, the generalized wake (which is also based on experimental data), and computational results derived using a generalized wake approach. The method has application to the flow past bodies in arbitrary motion, and it can easily be extended to the case of rotors in forward flight. R.R.

A88-13266
AERODYNAMIC ANALYSIS OF COMPLICATED THREE-DIMENSIONAL CONFIGURATIONS USING SURFACE PANEL METHODS
J. L. HESS (Douglas Aircraft Co., Long Beach, CA) IN: Betech 86; Proceedings of the Second Boundary Element Technology Conference, Cambridge, MA, June 17-19, 1986 . Southampton, England and Billerica, MA, Computational Mechanics Publications, 1986, p. 305-318. refs

The development of surface panel methods for the BEM analysis of complicated aerodynamic flow situations is reviewed, and recent applications in fields including aeronautics and automotive engineering are considered. With these methods the body is discretized by means of a large number of small plane quadrilateral panels on which the source and/or dipole strength is distributed in some fashion. It is noted that when large numbers of panels are employed, approximate expressions must be used for the influences of distant panels, and an iterative solution must be applied in solving linear equations. Specific applications of the panel method for the analysis of bodies such as transport aircraft propellers, surface ships, and underwater structures are discussed. R.R.

A88-13267
A HIGH ORDER PANEL METHOD FOR DETERMINING INCOMPRESSIBLE FLOWS AROUND ARBITRARY BODIES
Z. P. NOWAK (Warszawa, Politechnika, Warsaw, Poland) IN: Betech 86; Proceedings of the Second Boundary Element Technology Conference, Cambridge, MA, June 17-19, 1986 . Southampton, England and Billerica, MA, Computational Mechanics Publications, 1986, p. 319-327. refs

A higher-order boundary integral method for solving the exterior Neumann problem for the Laplace equation is proposed, with application to incompressible potential flows around three-dimensional bodies. The body is approximated by a closed polyhedron composed of plane triangular panels, and accurate and efficient flow velocity calculations are obtained by differentiating a bicubic spline fit to the potential values at the polyhedron vertices. Results are presented for the flow around a sphere and for the symmetric flow around an RAE wing with a NACA 0012 cross section. Pressure distributions on the surface of the wing are found to agree with previous results. R.R.

A88-13270* Boston Univ., Mass.
A BOUNDARY ELEMENT METHOD FOR UNSTEADY VISCOUS FLOWS
B. K. BHARADVAJ, L. MORINO, and S. DEL MARCO (Boston University, MA) IN: Betech 86; Proceedings of the Second Boundary Element Technology Conference, Cambridge, MA, June 17-19, 1986 . Southampton, England and Billerica, MA, Computational Mechanics Publications, 1986, p. 421-430. refs
(Contract NAG1-564)

A potential vorticity method for the analysis of unsteady viscous incompressible flow past arbitrarily shaped objects is discussed which is based on the Helmholtz decomposition. It is found that the correct boundary condition to be imposed is on the normal component of the velocity for the cases of both inviscid and viscous flows. The no-slip condition is shown to be automatically satisfied for viscous flows. Numerical solutions for two-dimensional flow problems are given for attached flows in addition to those involving separation. The vorticity is confined, at least for the case of symmetric flows, to a small region in the immediate vicinity of the body, making possible the minimization of the number of node points in the field, and hence the computational time, without loss of accuracy. R.R.

A88-13287
FLOW AROUND A CONE AT SUPERSONIC SPEED
DUN HUANG (Beijing University, People's Republic of China) IN: Progress in applied mechanics . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 83-89. refs

The inviscid supersonic conical flow around a cone at zero angle of attack is analyzed by the method of asymptotic expansion. The two kinds of parameter used are both small differences of angles. Asymptotic expansions up to the fourth order are obtained, and a comparison with the Table of Conical Flow (Kopal, 1947) is added. Comparison shows that for adequately high Mach number of incoming flow, the result of this paper is correct to four significant figures. Some possible applications are indicated. Author

A88-13429#
EXPERIMENTAL RESEARCH ON THE STRUCTURE AND 'BURSTING' OF EDDIES ON A SLENDER DELTA WING - CONDUCTED IN A WIND TUNNEL USING AN ACOUSTOOPTIC MEASUREMENT METHOD [EXPERIMENTELLE UNTERSUCHUNGEN DER STRUKTUR UND DES 'AUFPLATZENS' DER WIRBEL AN EINEM ANGESTELLTEN SCHLANKEN DELTAFLUEGEL - AUSGEFUEHRT IM WINDKANAL MITTELS EINER AKUSTISCHE-OPTISCHEN MESSMETHODE]

R. H. ENGLER (DFVLR, Goettingen, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 83-98. In German.

A newly developed acoustooptical method for studying the structure and bursting of the disturbance-sensitive eddies on delta wings is reported. The design of the test device for the method and of the test itself are briefly described. The evaluation of measurement results using the method is discussed, and experimental results using an eddy model are presented. C.D.

A88-13431#
EXPERIMENTAL INVESTIGATION OF SHOCK-BOUNDARY LAYER INTERFERENCE WITH PASSIVE INFLUENCE [EXPERIMENTELLE UNTERSUCHUNG DER STOSS-GRENZSCHICHTINTERFERENZ MIT PASSIVER BEEINFLUESSUNG]

R. BOHNING (Karlsruhe, Universitaet, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 140-145. In German.

Shock-boundary layer interference has a significant and deleterious effect on the aerodynamic characteristics of transonic airfoils. In this paper the first results of a series of measurements on the structure or the flow field in a region of such interference are presented. Schlieren photographs and Mach-interferograms of the interference regions are presented and discussed. C.D.

A88-13432#
EXPERIMENTAL INVESTIGATIONS ON DOUBLE DELTA WINGS UNDER ASYMMETRIC FLOW CONDITIONS [EXPERIMENTELLE UNTERSUCHUNGEN AN DOPPELDELTAFLUEGELN BEI UNSYMMETRISCHER STROEMUNG]

M. BEUKENBERG and D. HUMMEL (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 146-171. In German. Sponsorship: Bundesministerium der Verteidiging.
(Contract BMVG-T/RF-41/D0011/D1411)

The aerodynamic characteristics of a series of double delta wings under asymmetric flow conditions were investigated. Results are given for three wings with aspect ratios of 1.31, 2.05, and 3.01. While the geometry of the wing front section was kept constant, the sweepback angle of the rear section was systematically varied. The site of the break of the curve at the front edge was kept constant. The wings were treated as flat plates with rounded front edges. Six-component, pressure distribution, and flow field measurements are presented, and the visibility of the wall flow line is examined. The physical flow process is discussed, and the results are compared with theoretical findings. C.D.

A88-13433#
EXPERIMENTAL STUDIES ON CANARD CONFIGURATIONS [EXPERIMENTELLE UNTERSUCHUNGEN AN ENTENKONFIGURATIONEN]

H.-C. OELKER and D. HUMMEL (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 172-191. In German.
(Contract DFG-HU-254/8)

Preliminary results are presented of an experimental study of the interference between guidance and wings in closely-coupled duck configurations in incompressible and symmetric flow. Results of three-component measurements and findings on the suction-side pressure distributions are given and discussed. Pressure distributions for various angles of attack are given and the near-wall flow process is examined using wall shear stress pictures. The results show that a strong influence of the guidance on the wings retards flow separation at the front edge and increases in the rear area. The influence of the wings on the guidance increases with increasing angle of attack, inducing upwash and parallel winds. These results are compared with wind tunnel test results of the interference between guidance and wings. C.D.

A88-13434#
FORCE AND PRESSURE DISTRIBUTION MEASUREMENTS ON SUPPORTED, 65 DEG DELTA WINGS FOR SUBSONIC AND TRANSONIC MACH NUMBERS [KRAFT- UND DRUCKVERTEILUNGMESSUNGEN AN EINEM GESTUTZTEN 65 DEG-DELTAFLUEGEL BEI SUBSONISCHEN UND TRANSSONISCHEN MACHZAHLEN]

K. HARTMANN (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 278-284. In German.

A88-13435#
FLOW FIELD STUDY ON A 65 DEG DELTA WING

KARL A. BUETEFISCH, D. PALLEK, and J. REICHMUTH (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 285-302. refs

In this paper, Euler code predictive results on the flow field of delta wings are compared with experimentally obtained local flow field data. Force and pressure distribution measurements are used in addition to velocity measurements made with a three-component laser Doppler anemometer in a transonic wind tunnel. The wind tunnel and anemometer are described. The structure of the flow field and quantitative information on the positions of the vortices were obtained using a described laser sheet flow visualization technique. The quality of the flow visualization obtained with the Euler code is assessed. C.D.

A88-13436#
CALCULATION OF NONLINEAR AERODYNAMIC CHARACTERISTICS OF INTERFERING AIRFOILS USING AN EDDY CASCADE METHOD UNDER SUBSONIC FLOW CONDITIONS [BERECHNUNG NICHTLINEARER AERODYNAMISCHER CHARAKTERISTIKA VON INTERFERIERENDEN TRAGFLAECHEN MITTELS EINES WIRBELGITTERVERFAHRENS BEI UNTERSCHALLSTROEMUNG
CH. URBAN, R. BEHR, and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 303-316. In German. refs
(Contract DFG-WA-424/3)

An eddy cascade method for studying flow interference between wings and free eddy layers is described. The method is applicable to single or staggered wings, with or without eddy separation. Effects determinable by potential theory and results for wing loads obtained with the method are in good agreement with measurements. The method can be used to describe unsteady processes with small Strouhal numbers. It offers the possibility for extensive predictions about flow interference with small computer costs. C.D.

A88-13437#
STABILITY ANALYSIS AS AN AID IN THE DESIGN OF LAMINAR PROFILES [DIE STABILITAETSANALYSE ALS HILFSMITTEL BEIM ENTWURF VON LAMINARPROFILEN]
G. REDEKER and K.-H. HORSTMANN (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 317-348. In German. refs

The possibility of applying laminar profile technology at higher Mach and Reynolds numbers to design swept-back wings is considered. The upset mechanism in swept-back wings is discussed, and the use of stability analysis in the design of laminar profiles is addressed. Design guidelines for laminar profiles are examined, and experimental studies to determine the N-boundary values are reviewed. C.D.

A88-13544#
NUMERICAL SOLUTIONS OF THE EULER EQUATIONS FOR THE FLOW FIELD AROUND COUNTER-ROTATING PROPELLERS
MAKOTO KOBAYAKAWA and MASAHIRO NAKAO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 403, 1987, p. 389-398. In Japanese, with abstract in English. refs

In order to investigate the flow field around the ATP through numerical methods for its optimal design, 3D-Euler equations are most prominent. The flow field around counterrotating propellers in advancing 0.8 Mach is obtained. Two spaces including front and rear blades are solved separately. The interaction between both blades are taken into the calculation by the connecting surfaces. The noniterative implicit ADI scheme is used in order to solve Euler equations. The periodic steady and averaged steady solutions are obtained. The latter is simplified by averaging the variables at the connecting surface. This shortens the calculation time to one-third compared with the periodic steady analysis which simulates the relative motion of the blades exactly. Numerical calculations are performed for two counter rotating ATP's with SR-1 and SR-3 blades. Both results show that they are similar to each other, and the propeller efficiencies increase compared with single rotating ATP with same blades. Author

A88-13545#
ADDENDUM TO THE CALCULATION OF TRANSONIC POTENTIAL FLOW THROUGH A TWO-DIMENSIONAL CASCADE
KENJI INOUE and TAKASHI NAKAMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 403, 1987, p. 399, 400. In Japanese, with abstract in English. refs

Two things to be added to a previously published paper on the calculation of the transonic potential flow through a two-dimensional cascade are stated. The first is a calculation procedure to obtain the solution in which a given point on a blade is a stagnation point without giving the downstream condition. The second is the relation between the force acting on a blade, the distribution of pressure on its surface, the circulation around it, and the up- and downstream conditions. Author

A88-13546#
A DESIGN OF THE CASCADE FOR A SHOCK-IN-ROTOR SUPERSONIC AXIAL-FLOW COMPRESSOR
TAKAAKI HASHIMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 403, 1987, p. 401-404. In Japanese, with abstract in English. refs

A design method of the cascade for a shock-in-rotor supersonic axial-flow compressor is presented. The inlet flow is uniform and satisfies simplified radial equilibrium. The flow just before the normal shock is uniform and satisfies simplified radial equilibrium. The supersonic portion between the inlet and the normal shock is designed by using the method of weak wave. In the subsonic portion the flow is quasi-axisymmetric. The shape of mean streamline is assumed to be circular arc. The passage walls are composed of circular arcs. A two-dimensional supersonic cascade which is designed by the method in this report includes the three-dimensional effect by taking into account radial equilibrium conditions. Author

A88-13740
DEVELOPMENT OF AERODYNAMICS RESEARCH AT THE INSTITUTE OF THEORETICAL AND APPLIED MECHANICS OF THE SIBERIAN BRANCH OF THE ACADEMY OF SCIENCES OF THE USSR [RAZVITIE AERODINAMICHESKIKH ISSLEDOVANII V ITPM SO AN SSSR]
V. G. DULOV, V. IA. LEVCHENKO, and A. M. KHARITONOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1987, p. 86-106. In Russian. refs

Results of theoretical and experimental studies in aerodynamics carried out at the Institute of Theoretical and Applied Mechanics of the Siberian Branch of the Academy of Sciences of the USSR are reviewed. Attention is given to developments in the areas of turbulence, separated and complex subsonic and supersonic turbulent flows, and some important results obtained in the field of hypersonic aerodynamics. The discussion includes a description of the experimental aerodynamic facilities developed by the Institute. V.L.

A88-13741
DIFFRACTION OF AN OBLIQUE SHOCK WAVE IN THE VICINITY OF AN EXTERNAL RIGHT-ANGLE CORNER [DIFRAKTSIIA KOSOGO SKACHKA UPLOTNENIIA V OKRESTNOSTI VNESHNEGO PRIAMOGO UGLA]
A. I. MAKSIMOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1987, p. 146-156. In Russian. refs

An analysis is made of longitudinal supersonic flow past an external two-sided corner, with and without interaction with an obliquely incident shock wave, at freestream Mach 2.27. Based on an analysis of pressure distribution measurements on the model surface and flow visualization studies by different techniques, most probable schemes of flow development in the vicinity of the diffraction edge are proposed. V.L.

A88-13759
AN EXPERIMENTAL STUDY OF THE STABILITY OF A SUPERSONIC BOUNDARY LAYER ON A CONE [EKSPERIMENTAL'NOE ISSLEDOVANIE USTOICHIVOSTI SVERKHZUKOVOGO POGRANICHNOGO SLOIA NA KONUSE]
A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Aug. 1987, p. 64-69. In Russian. refs

An experimental study is made of the stability of a supersonic boundary layer on a cone against both natural and artificial perturbations. The spatial characteristics of the wave perturbation field of a supersonic boundary layer on a cone are determined, and it is shown that the evolution of perturbations on a cone is similar to the development of perturbations in a boundary layer on a flat plate. It is suggested that the difference in the Reynolds number of the transitions on a cone and on a plate may be due to both the lesser degree of the spatial amplification of perturbations on a cone and the difference in the nature of perturbation generation. V.L.

A88-13761
MODELING OF LARGE-SCALE VORTEX STRUCTURES IN SUPERSONIC TURBULENT FLOW PAST BLUNT BODIES [MODELIROVANIE KRUPNOMASSHTABNYKH VIKHREVYKH STRUKTUR PRI TURBULENTNOM OBTEKANII ZATUPLENNYKH TEL SVERKHZVUKOVYM POTOKOM]
I. A. BELOV, S. A. ISAEV, V. N. KONOVALOV, and A. IU. MITIN (Leningradskii Mekhanicheskii Institut, Leningrad, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Aug. 1987, p. 101-107. In Russian. refs

Large-scale vortex structures formed in supersonic flow past a cylinder, with a needle and a disk mounted in front of it, are modeled numerically and physically using the concept of an inviscid compressible gas with a specified turbulent shear layer at the separation zone boundary. A full system of Reynolds and energy equations is used for the mixing layer; the system is closed by a convective turbulence model. Parametric calculations are carried out to determine the effect of the body geometry and incoming flow Mach number on the wave drag coefficient and static pressure profiles at the cylinder end. The results obtained show that the approach proposed here is capable of correctly reproducing separated flow past a body. V.L.

A88-13957
AN UNSTEADY LIFTING-LINE THEORY
P. D. SCLAVOUNOS (MIT, Cambridge, MA) Journal of Engineering Mathematics (ISSN 0022-0833), vol. 21, no. 3, 1987, p. 201-226. Navy-supported research. refs
(Contract NSF MEA-82-10649-A01)

A lifting-line theory is developed for wings of large aspect ratio undergoing time-harmonic oscillations, uniformly from high to low frequencies. The method of matched asymptotic expansions is used to enforce the compatibility of two approximate solutions valid far from and near the wing surface. The far-field velocity potential is expressed as a distribution of normal dipoles on the wake, and its expansion near the wing span leads to an expression for the oscillatory downwash. The near-field flow is two-dimensional. A particular solution is obtained from strip theory and a homogeneous component is added to account for the spanwise hydrodynamic interactions. The compatibility of the inner and outer solutions leads to an integral equation for the distribution of circulation along the wing span. In the zero-frequency limit it reduces to that in Prandtl's lifting-line theory, and for high frequencies it tends to the two-dimensional strip theory. Lift computations are presented for an elliptic and a rectangular wing of aspect ratio A = 4. Author

A88-14016#
THE THEORETICAL MODEL AND NUMERICAL SOLUTION FOR THE COMPRESSIBLE VISCOUS VORTEX CORES
BINGQIU LIN (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Sept. 1987, p. 235-243. In Chinese, with abstract in English. refs

Based on the dimensional analysis, the parabolic equation of a compressible viscous vortex core has been derived. A simpler numerical method described here can be used to calculate the subsonic, transonic, and supersonic vortex motions. Numerical results for two examples are also shown, one for the expanding motion of the stable vortex and the other for the contracting motion of the stable vortex. Author

A88-14017#
A MIXED DIRECT-INVERSE PROBLEM OF THE TRANSONIC CASCADE
WEI LIU (Beijing Institute of Aerodynamics, People's Republic of China) and MENGYU SHEN (Tsinghua University, Beijing, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Sept. 1987, p. 244-250. In Chinese, with abstract in English. refs

A computational method is used to solve the mixed direct-inverse problem of a transonic plane cascade. It is based on the finite volume method and solves Euler equations directly. In effect the flow field in which shocks exist can be studied. The present method can be used in a wider range than the transonic relaxation method. K.K.

A88-14021#
ZERO-LIFT DRAG PREDICTIONS IN SUPERSONIC FLOW FOR COMPLEX CONFIGURATIONS
QIDE YANG and MINGSHENG MA (China Aerodynamic Research and Development Centre, Mianyang, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Sept. 1987, p. 293-297. In Chinese, with abstract in English. refs

A supersonic zero-lift drag computer program was developed for complex missilelike body shapes. A mixed method was developed for wave drag prediction. Van Dyke's (1952) second-order perturbation theory is used to compute the pressure distribution and resulting wave drag of the main body. The wave drag of the complete configuration is obtained via the product of the wave drag of the main body and the interference factors. K.K.

A88-14023#
THE CALCULATION OF AEROFOIL FRICTION DRAG IN COMPRESSIBILITY VISCOUS FLOW
JIAXIANG YAN, ZHIDE QIAO, and YONG YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Sept. 1987, p. 306-310. In Chinese, with abstract in English. refs

The calculation method of the aerofoil friction drag in a compressibility viscous flow is studied in this paper, including the calculation of the laminar boundary layer in the front of the aerofoil by the modified Thwaites (1949) method and the calculation of turbulent boundary layer by Green's (1972) method. According to these methods, two aerofoil drag coefficients have been calculated under different Reynolds numbers and Mach numbers. Author

A88-14105*# Old Dominion Univ., Norfolk, Va.
SUPERCOMPUTING OF SUPERSONIC FLOWS USING UPWIND RELAXATION AND MACCORMACK SCHEMES
O. BAYSAL (Old Dominion University, Norfolk, VA) IN: Applications of parallel processing in fluid mechanics; Proceedings of the Applied Mechanics, Bioengineering, and Fluids Engineering Conference, Cincinnati, OH, June 14-17, 1987 . New York, American Society of Mechanical Engineers, 1987, p. 27-35. refs
(Contract NAG1-664)

The performance of two numerical solution schemes, (1) an implicit upwind relaxation with a finite-volume discretization (Thomas and Walters, 1985) and (2) an explicit-implicit

MacCormack (1981) scheme with a finite-difference discretization, is compared in two-dimensional simulations of supersonic flow past a flat plate with leading edge, a rearward-facing step, a 10-deg compression corner, a NACA 0012 airfoil at high angle of attack, and a cavity. The algebraic turbulence model, the solution methods, and the boundary conditions and SIMD coding are explained, and the results are presented in tables and graphs and characterized with reference to published experimental data. Scheme (1) is found to converge more rapidly and to give more accurate results than (2) in a wide range of problem types. T.K.

A88-14108*# Old Dominion Univ., Norfolk, Va.
PERFORMANCE OF A THREE-DIMENSIONAL NAVIER-STOKES CODE ON CYBER 205 FOR HIGH-SPEED JUNCTURE FLOWS
B. LAKSHMANAN and S. N. TIWARI (Old Dominion University, Norfolk, VA) IN: Applications of parallel processing in fluid mechanics; Proceedings of the Applied Mechanics, Bioengineering, and Fluids Engineering Conference, Cincinnati, OH, June 14-17, 1987 . New York, American Society of Mechanical Engineers, 1987, p. 65-74. refs
(Contract NAS1-53003)

A vectorized 3D Navier-Stokes code has been implemented on CYBER 205 for solving the supersonic laminar flow over a swept fin/flat plate junction. The code extends MacCormack's predictor-corrector finite volume scheme to a generalized coordinate system in a locally one dimensional time split fashion. A systematic parametric study is conducted to examine the effect of fin sweep on the computed flow field. Calculated results for the pressure distribution on the flat plate and fin leading edge are compared with the experimental measurements of a right angle blunt fin/flat plate junction. The decrease in the extent of the separated flow region and peak pressure on the fin leading edge, and weakening of the two reversed supersonic zones with increase in fin sweep have been clearly observed in the numerical simulation. Author

A88-14109*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATION OF SUBSONIC BASE FLOW ON A VECTOR PROCESSOR
D. H. RUDY (NASA, Langley Research Center, Hampton, VA) IN: Applications of parallel processing in fluid mechanics; Proceedings of the Applied Mechanics, Bioengineering, and Fluids Engineering Conference, Cincinnati, OH, June 14-17, 1987 . New York, American Society of Mechanical Engineers, 1987, p. 75-83. refs

Two-dimensional subsonic laminar compressible base flow has been studied using numerical solutions of the time-dependent Navier-Stokes equations. These solutions were obtained using an explicit finite-difference scheme which is highly efficient on a vector processor. The organization of the code for a CDC CYBER-205 computer is described. Solutions were obtained for Mach 0.4 and 0.6 flows past a slender blunt-based model at moderately high Reynolds numbers. The flow in the wake is unsteady with periodic shedding of vortices from the trailing edge. The computed shedding frequency was found to increase with increasing Reynolds number. Author

A88-14126#
COMPUTATIONS OF A TURBULENT JET-EDGE FLOW FIELD
P. S. BERNARD (Maryland, University, College Park) IN: Forum on Turbulent Flows - 1987, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 13-17. refs

Recent studies have elucidated the underlying vortical structure of a self-excited oscillatory jet impinging on a sharp edged wedge under laminar conditions. The present work analyzes this system at a Reynolds number, R = 2000, for which turbulent phenomena are expected to be present and of significance. Numerical solutions to the closed system of equations constituting the Mean Vorticity and Covariance closure were obtained using a vectorizable algorithm on a CRAY XMP/48 supercomputer. The observed pattern of vortical events in front of the wedge tip differed significantly from lower Reynolds number solutions. The dynamically important wedge tip and nozzle lip regions were the sites of most intense turbulence activity. Stage 2 behavior characterized the dominant motions of the jet while an intermittent high frequency oscillation was also observed. This may be a precursor to the stage 3 type flow which is expected near the simulation Reynolds number. Author

A88-14128#
INTERACTIONS OF A TWO-DIMENSIONAL VORTEX WITH A WALL LAYER OF VORTICITY
R. W. BARTHOLOMEW, K. PAN, and S. M. BAJOREK (Michigan State University, East Lansing) IN: Forum on Turbulent Flows - 1987, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 25-30. refs

The interaction of a two-dimensional vortex linepair with a wall layer of vorticity was studied using a vortex-in-cell computation. The interactions, ranging from mild disturbances to violent rearrangements of the wall layer vorticity, are characterized using three dimensionless parameters: the angle at which the vortex linepair is introduced, the ratio of the length scales for the linepair and the wall layer thickness, and the ratio of the characteristic velocities. The nature of the interactions are illustrated through comparisons with vortex ring/wall experiments and by vector velocity plots which show the rollup of wall layer fluid, the formation of depressions in the vorticity layer, and/or the breakup of the vortex linepair. These three phenomena all have analogs in the bursting process of turbulent boundary layers. Thus, while the two-dimensional model lacks the vortex stretching of a truly turbulent boundary layer, the model proves itself a valuable tool for gaining insight into a number of phenomena associated with the turbulent production process. Author

A88-14134*# Old Dominion Univ., Norfolk, Va.
CALCULATION OF WALL AND FREE TURBULENT-SHEAR FLOWS AT SUPERSONIC SPEEDS
O. BAYSAL and S. SRINIVASAN (Old Dominion University, Norfolk, VA) IN: Forum on Turbulent Flows - 1987, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 55-60. refs
(Contract NAG1-664)

Supersonic turbulent flows are simulated numerically by solving the Reynolds-averaged full Navier-Stokes equations by an implicit finite-volume method. This flux-vector-split upwind scheme uses approximate factorization followed by line-Gauss-Seidel relaxations. The effects of turbulence are modeled by two eddy viscosity models. High-Reynolds-number form of the k-epsilon model is coupled with a wall-function to avoid excessive refinement of the grid in the low-Reynolds number regions. The k-epsilon equations are solved by the explicit-implicit MacCormack method. The algebraic Baldwin-Lomax model is also being used as an inexpensive alternative for the cases which do not experience massive separation. Several examples of two-dimensional solutions are given to illustrate both wall and free turbulent shear flows which include fluid dynamic phenomena, such as shocks, boundary layers, shear layers, wakes, separations and recirculations. The results compared with experimental data show good agreeent. Author

A88-14144#
RESPONSE OF A DELTA WING IN STEADY AND UNSTEADY FLOW
M. LEE, CHIANG SHIH, and CHIH-MING HO (Southern California, University, Los Angeles, CA) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 19-24. refs
(Contract F49620-85-C-0080)

This paper is concerned with the response of a delta wing under periodic acceleration and deceleration of the free stream velocity. The experiments were carried out in a vertical water channel where the free stream velocity was varied close to a triangular pattern. Flow visualizations indicated that the leading edge vortex on top of the delta wing was not drastically affected

by the imposed unsteady free stream. Lift measurements suggested that the unsteady lift coefficient followed the variation of the time derivative of the free stream velocity. Author

A88-14146#
VORTEX DYNAMICS OF SLENDER WINGS AS A NUMERICAL EXPERIMENT WITH DISCRETE-VORTEX METHODS
H. K. CHENG and Z. X. JIA (Southern California, University, Los Angeles, CA) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 35, 36. refs
(Contract AF-AFOSR-85-0318)

The problem of an unsteady, massively separated flow about a flat plate at normal incidence is numerically investigated with discrete-vortex methods in order to study the vortex dynamics of a slender delta wing. For the case of a uniformly expanding plate corresponding to a flat delta wing, the present solution is shown to accurately recover the conical-flow symmetry. Good agreement is found with corresponding data for a delta wing in steady flow obtained using Euler and potential codes. R.R.

A88-14147#
STEADY AND UNSTEADY AERODYNAMIC INTERFERENCE IN CLOSELY COUPLED CANARD/WING CONFIGURATIONS
J. ELZEBDA, D. T. MOOK, and A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 37-44. refs

A versatile method based on the general unsteady vortex-lattice technique was developed in a previous paper. This method models flows over an arbitrary number of lifting surfaces. Further use of this method is considered in this paper. The X-29 (two canards and main wing) is used as a model, and simulations of the steady and unsteady aerodynamic interference are presented. A comparison of the static aerodynamic load with wind-tunnel data shows good agreement. The present investigation also yields the time histories of the aerodynamic loads on the lifting surfaces for a sinusoidal motion. The results show the strong influence of the canards on the main wing, including the time lag between the motion of the canards and the subsequent changes in the pressure distributions and loads on the main wing. Author

A88-14150#
UNSTEADY SEPARATION AT LOW REYNOLDS NUMBERS
H. REED (Arizona State University, Tempe) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 65, 66. refs
(Contract N00014-84-K-0232; N00014-86-K-0066)

The response of a laminar two-dimensional, incompressible boundary-layer flow to an applied unsteady freestream pressure gradient is analytically and computationally investigated. Triple-deck theory is used to analyze the separation location and structure, in addition to the rate at which the separated regions develop. The theory is used to generate velocity profiles and to study the temporal behavior of bubble development. R.R.

A88-14155*# Dayton Univ., Ohio.
NUMERICAL SIMULATION OF SELF-SUSTAINED AND FORCED OSCILLATIONS IN JET SHEAR LAYERS
J. N. SCOTT (Dayton, University, OH) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 123-130. refs
(Contract NAG3-526)

Excitation of axisymmetric jet shear layers has been investigated by solving the time-dependent compressible Navier-Stokes equations. MacCormack's explicit finite difference scheme is used in performing the computations on a CRAY X-MP computer. This work examines the influence of various means of excitation of the shear layer, to produce large scale vortex structures in such a manner that the mixing between two flows will be enhanced or diminished. While successful pressure excitation has been achieved in previous studies only limited success with temperature excitation at the inflow boundary has been accomplished. The current study focuses on the use of temperature excitation through the boundary layer immediately inside the jet lip. In order to achieve the required resolution significant grid refinement is necessary. The results of the computation with and without temperature excitation are analyzed and compared with results obtained using pressure excitation. The influence of amplitude and frequency on specific flow characteristics are also examined. The excitation frequency for both the temperature and pressure corresponds to a Strouhal number of .45 and the inflow jet Mach number is approximately .3. Author

A88-14159*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DETAILS OF THE COMPUTED FLOWFIELD OVER A CIRCULAR CYLINDER AT REYNOLDS NUMBER 1200
C. L. RUMSEY (NASA, Langley Research Center, Hampton, VA) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 175-185. refs

The application of an upwind-biased implicit approximate factorization Navier-Stokes algorithm to the unsteady impulsive start-up flow over a circular cylinder at Reynolds number 1200 is described. The complete form of the compressible Navier-Stokes equations is used, and the algorithm is second-order accurate in both space and time. The development with time of the shape and size of the separated vortical flow region is computed, as well as the time-variation of several boundary layer parameters and profile shapes. Computations, in general, show excellent agreement with experiment, although the present method predicts a more rapid onset of reversed flow on the cylinder than evidenced in experiment. The changes that the vortical region behind the cylinder undergoes as the symmetric flow transitions to periodic vortex shedding are discussed. The flow becomes periodic with a Strouhal frequency of 0.222, which compares well with the experimental value of approximately 0.21. The effect of grid density on the development of the unsteady flow is also shown. Author

A88-14160*# Cincinnati Univ., Ohio.
ANALYSIS OF UNSTEADY WAKE OF A CIRCULAR CYLINDER USING NAVIER-STOKES EQUATIONS
K. N. GHIA, C. A. LIU, U. GHIA, and G. A. OSSWALD (Cincinnati, University, OH) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 187-190. refs
(Contract AF-AFOSR-85-0231; AF-AFOSR-87-0074; NAG1-465)

An unsteady Navier-Stokes analysis of the separated flow in the wake of a circular cylinder is presented in order to study the wake structure and the various interactions between its scales at low Re. The quasi-periodic and chaotic flows noted by Sreenivasan (1985) are searched for. The analysis is used to characterize the secondary vortex formation in the early stages of the flow development and its interaction with the primary vortex. R.R.

A88-14161#
FEATURES OF TRANSITIONAL SEPARATION BUBBLES IN AN OSCILLATING FREESTREAM
M. BRENDEL and T. J. MUELLER (Notre Dame, University, IN) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 191-197. Research supported by the University of Notre Dame. refs
(Contract N00014-83-K-0239)

Wind tunnel experiments were conducted to study the transitional separation bubbles on an airfoil in steady and streamwise unsteady flow. Hot-wire anemometry data were obtained on a FX63-137 airfoil operating with a mean chord Reynolds number of 100,000. A programmable damper system was used to produce a streamwise periodic variation in the wind tunnel speed. Mean unsteady and phase-locked velocity profiles

were obtained for a base flow having an oscillation period of 0.5 seconds and an amplitude of 7 percent of the mean flow. The mean unsteady displacement thicknesses in the separated laminar shear layer of the transitional bubble were lower than the steady values while the mean unsteady momentum thicknesses did not show measureable differences. Author

A88-14162#
ON THE UNSTEADY FLOW PAST AN IMPULSIVELY STARTED AIRFOIL AT A HIGH ANGLE OF ATTACK
L. M. LOURENCO, M. S. CHANDRASEKHARA, and A. KROTHAPALLI (Florida State University, Tallahassee) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 199.
(Contract AF-AFOSR-86-0243)

A88-14163#
THE EFFECT OF PITCH LOCATION ON DYNAMIC STALL
E. J. JUMPER (USAF, Institute of Technology, Wright-Patterson AFB, OH), R. L. DIMMICK (USAF, Wright-Patterson AFB, OH), and A. J. S. ALLAIRE (Canadian Armed Forces, Canada) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 201-208. refs

A theoretical and wind tunnel investigation of the effect of pitch location on dynamic stall is presented for an airfoil pitching at constant rate. Theoretical data were obtained using a modified momentum-integral method, and experimental time-varying pressure data were obtained from 16 locations on an NACA 0015 airfoil. The data were used to determine dynamic-stall effects of change in the angle of attack at which separation occurs at the quarter chord, and change in the angle of attack at which stall occurs. The results indicate a nondimensional pitch rate given by the chord times the pitch rate divided by two times the freestream velocity. R.R.

A88-14164#
FLOW DEVELOPMENT ON A JOUKOWSKI AIRFOIL STARTED IMPULSIVELY FROM REST
R. ROJAS-OVIEDO and J. C. WILLIAMS, III (Auburn University, AL) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 209-214. Research supported by the Instituto Politecnico National and Auburn University. refs

A study is made of the unsteady laminar boundary layer development on a symmetrical Joukowski airfoil at zero angle of attack, impulsively set into uniform motion. The boundary layer development is calculated using an implicit finite difference technique. Special attention is paid to the growth of the boundary layer near the airfoil trailing edge and to the nature of the separation singularity. It is shown that as time increases a bubble of recirculating fluid forms near the trailing edge, increases size as time increases, until finally it extends beyond the trailing edge of the airfoil. The computed characteristics of the boundary layer support the concept of a spontaneous singularity at separation which appears at a dimensionless time of approximately 4.3 at approximately 0.7 chord. From this point the separation moves fairly rapidly to the steady state separation point at approximatley .500 chord. The effects of certain numerical parameters on the numerical calculation and on the computed boundary layer characteristics are also investigated. Author

A88-14246#
UNSTEADY NEWTONIAN FLOW OVER TWO-DIMENSIONAL AIRFOILS
HAMDI T. HEMDAN (King Saud University, Riyadh, Saudi Arabia) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 30, Aug. 1987, p. 65-79. Research sponsored by King Saud University. refs

A Newtonian theory is developed for two-dimensional airfoils performing small amplitude pitching oscillations. Closed-form results are obtained for the unsteady pressure and the aerodynamic derivatives. Surface curvature is found to decrease the damping derivative for certain pivoting positions or even to make the wing dynamically unstable. Author

A88-14250#
ON STEADY SUPERSONIC FLOW OVER TWO-DIMENSIONAL AIRFOILS
HAMDI T. HEMDAN (King Saud University, Riyadh, Saudi Arabia) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 30, Aug. 1987, p. 111-129. Research supported by King Saud University. refs

The problem of steady supersonic flow over two-dimensional airfoils with attached shock waves is considered. By combining the Newtonian limit with a geometric limiting process, new approximate equations are derived which can be used for a wide range of supersonic flows. Newtonian flow can be recovered from those equations as a special case. The work is restricted to moderate supersonic flow only for which two systems of linearized equations are derived and used to obtain closed-form formulas for the coefficient of surface pressure and other aerodynamic parameters. The results are compatible with the theory of characteristics and experiments and improve over other existing approximate methods. Author

A88-14251*# New York Univ., New York.
A FAST APPROACH TO DESIGNING AIRFOILS FROM GIVEN PRESSURE DISTRIBUTION IN COMPRESSIBLE FLOWS
PRABIR DARIPA (New York University, NY) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 8 p. refs
(Contract NSG-1617; AF-AFOSR-83-0336; DE-AC02-76ER-03007)
(AIAA PAPER 87-2862)

A new inverse method for aerodynamic design of airfols is presented for subcritical flows. The pressure distribution in this method can be prescribed as a function of the arc length of the as-yet unknown body. This inverse problem is shown to be mathematically equivalent to solving only one nonlinear boundary value problem subject to known Dirichlet data on the boundary. The solution to this problem determines the airfoil, the freestream Mach number, and the upstream flow direction. The existence of a solution to a given pressure distribution is discussed. The method is easy to implement and extremely efficient. A series of results for which comparisons are made with the known airfoils is presented. Author

A88-14278#
AN EXPERIMENTAL INVESTIGATION OF WING/FUSELAGE INTEGRATION GEOMETRIES
MARK D. MAUGHMER (Pennsylvania State University, University Park) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 10 p. refs
(AIAA PAPER 87-2937)

Although long recognized as a significant contributor to overall drag, a great deal of work yet remains to be done on understanding and controlling the interference flowfield generated by the wing/fuselage intersection. As the increasing use of composite structures allows more and more complicated geometries to be realized, the possibility exists for the very careful blending of the wing/fuselage region such that the impact of the juncture on the flow is minimized. Specifically, it is found that a leading-edge extension of the airfoil in the vicinity of the wing root decreases the size and strength of the vortex which generally forms in this region. To investigate such wing/fuselage integration, an experimental program has been performed in which flow visualization, pressure distributions, and force-balance data were obtained and used to define the most promising juncture geometries. These experiments indicate that the juncture flow is very sensitive to the wing/fuselage intersection geometry, and the proper shaping of this region can lead to a significant drag reduction. Author

A88-14306
AIRSHIP LIFT - STATIC, DYNAMIC AND POWERED STATIC
DONALD M. LAYTON (U.S. Naval Postgraduate School, Monterey, CA) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 1 . London, Royal Aeronautical Society, 1986, p. 7.1 to 7.14. refs

A comprehensive evaluation is made of the consequences for airship lift performance, maneuverability, and aerodynamic efficiency of the various modes of interaction between basic static lift capacity and both propulsion system-generated lift and incidence in forward motion-induced dynamic lift. It was demonstrated as far back as the 1920s that a classic airship hull generates less than 20 percent of the dynamic lift obtainable at incidence; the rest comes from the horizontal fins and stabilizers. Attention is given to the effects of lift gas superheating and the usefulness of negative dynamic lift in maintaining equilibrium flight. O.C.

A88-14458
ORGANIZED STRUCTURES IN A COMPRESSIBLE, TURBULENT BOUNDARY LAYER
ERIC F. SPINA and ALEXANDER J. SMITS (Princeton University, NJ) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 182, Sept. 1987, p. 85-109. refs
(Contract AF-AFOSR-85-0126)

The boundary layer behavior of a compressible flow was studied using a high-Reynolds-number supersonic blowdown wind tunnel. Four miniature differential pressure transducers were used to measure wall-pressure fluctuations, while constant-temperature hot-wire anemometers were used to measure the instantaneous mass flux. The results show qualitative similarity between the compressible boundary layer and the incompressible flows investigated previously. It was found that large-scale structures exist in the boundary layer, with heights comparable to the boundary-layer thickness. The structures maintain their shape as they travel downstream. The angle of 45 deg inferred from correlations between two hot wires, and between a hot wire and a wall-pressure transducer, indicates that the average structure is inclined at approximately 45 deg to the wall. This result agrees well with observations of structures in schlieren photographs of supersonic boundary layer. I.S.

A88-14459* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF ACOUSTIC EXCITATION ON THE FLOW OVER A LOW-RE AIRFOIL
K. B. M. Q. ZAMAN (NASA, Lewis Research Center, Cleveland, OH), A. BAR-SEVER (NASA, Langley Research Center, Hampton, VA), and S. M. MANGALAM (NASA, Langley Research Center; AS & M, Inc., Hampton, VA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 182, Sept. 1987, p. 127-148. refs
(Contract NAS1-17670; NAS1-17683)

Wind-tunnel measurements of lift, drag, and wake velocity spectra were carried out under (tonal) acoustic excitation for a smooth airfoil in the chord-Reynolds-number Re(c) range of 40,000-140,000. The data were supported by smoke-wire flow-visualization pictures. Small-amplitude excitation in a wide, low-frequency range is found to eliminate laminar separation that otherwise degrades the airfoil performance at low Re(c) near the design angle of attack. Excitation at high frequencies eliminates a prestall, periodic shedding of large-scale vortices. Significant improvement in lift is also achieved during poststall, but with large-amplitude excitation. Wind-tunnel resonances strongly influence the results, especially in cases requiring large amplitudes. Author

A88-14461* Princeton Univ., N. J.
EXPERIMENTAL STUDY OF THREE SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTIONS
ALEXANDER J. SMITS and KIN-CHOONG MUCK (Princeton University, NJ) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 182, Sept. 1987, p. 291-314. refs
(Contract NAGW-240; AF-AFOSR-85-0126)

The paper presents a systematic study of the supersonic flow of a turbulent boundary layer over several compression-corner models. The wind tunnel and the compression-corner models (ramps fitted with aerodynamic fences to minimize three-dimensional effects) were identical with those used by Settles et al. (1979); constant-temperature hot-wire anemometry was used for the mass-flow measurements. The turning angles used for the compression corners were 8, 16, and 20 deg. In all three flow cases, the shock wave/turbulent flow interaction did amplify the turbulent stresses dramatically, with amplification increasing with increasing turning angle. However, different stress components were amplified by different amounts. I.S.

A88-14678
HYDRODYNAMIC CHARACTERISTICS OF A RIGID RECTANGULAR OSCILLATING WING [O GIDRODINAMICHESKIKH KHARAKTERISTIKAKH ZHESTKOGO PRIAMOUGOL'NOGO KOLEBLIUSHCHEGOSIA KRYLA]
V. N. GLUSHKO (AN USSR, Institut Gidromekhaniki, Kiev, Ukrainian SSR) Gidromekhanika (ISSN 0367-4088), no. 56, 1987, p. 43-47. In Russian. refs

Experimental setup and procedure are described which have been used to measure the hydrodynamic thrust developed by a rigid rectangular oscillating wing, NACA-0015, over a wide range of hydrodynamic characteristics under conditions of reversed motion. The effect of angular and transverse wing oscillations on the hydrodynamic thrust is examined. Expressions are presented which relate the hydrodynamic thrust to the wing oscillation frequency and incoming flow velocity. V.L.

A88-14848*# Old Dominion Univ., Norfolk, Va.
THE GOERTLER INSTABILITY ON AN AIRFOIL
S. M. MANGALAM (Old Dominion University, Norfolk, VA), J. R. DAGENHART, J. F. MEYERS (NASA, Langley Research Center, Hampton, VA), and T. E. HEPNER (U.S. Army, Army Aviation Research and Development Command, Hampton, VA) AIAA, Aerospace Sciences Meeting, 23rd, Reno, NV, Jan. 14-17, 1985. 10 p. refs
(Contract NAG1-353)
(AIAA PAPER 85-0491)

Goertler vortices arise in boundary layers along concave surfaces due to centrifugal effects. This paper presents some results of an experiment conducted to study the development of these vortices on an airfoil with a pressure gradient in the concave region where an attached laminar boundary layer was insured with suction through a perforated panel. The sublimating chemical technique was used to visualize Goertler vortices and the velocity field was measured by laser velocimetry. The vortex wavelength clearly varied with Goertler number as predicted by linear theory. Both flow visualization and velocity measurements indicated vortex damping in the convex zone. Secondary instability was observed at the higher Goertler numbers. Author

A88-15205* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A PERSPECTIVE OF COMPUTATIONAL FLUID DYNAMICS
PAUL KUTLER (NASA, Ames Research Center, Moffett Field, CA) IN: BAIL IV; Proceedings of the Fourth International Conference on Boundary and Interior Layers - Computational and Asymptotic Methods, Novosibirsk, USSR, July 7-11, 1986 . Dun Laoghaire, Ireland, Boole Press, 1986, p. 332-348. Previously announced in STAR as N86-28057. refs

Computational fluid dynamics (CFD) is maturing, and is at a stage in its technological life cycle in which it is now routinely applied to some rather complicated problems; it is starting to create an impact on the design cycle of aerospace flight vehicles and

their components. CFD is also being used to better understand the fluid physics of flows heretofore not understood, such as three-dimensional separation. CFD is also being used to complement and is being complemented by experiments. In this paper, the primary and secondary pacing items that govern CFD in the past are reviewed and updated. The future prospects of CFD are explored which will offer people working in the discipline challenges that should extend the technological life cycle to further increase the capabilities of a proven demonstrated technology.
Author

A88-15501*# Queensland Univ., Brisbane (Australia).
DESIGN OF THREE-DIMENSIONAL SCRAMJET INLETS FOR HYPERSONIC PROPULSION
J. M. SIMMONS (Queensland, University, Brisbane, Australia) and E. H. WEIDNER (NASA, Langley Research Center, Hampton, VA) IN: *National Space Engineering Symposium, 2nd, Sydney, Australia*, Mar. 25-27, 1986, Preprints. Volume 1. Barton, Australia/Brookfield, VT, Institution of Engineers, Australia/Brookfield Publishing Co., 1986, 10 p. refs
(Contract NAGW-674)

The paper outlines an approach to the design of three-dimensional inlets for scramjet engines. The basis of the techniques used is the method of streamline tracing through an inviscid axisymmetric flow field. A technique is described for making a smooth change of cross-section shape from rectangular to circular. A feature is the considerable use of computer-graphics to provide a 'user-oriented' procedure which can produce promising design configurations for subsequent analysis with CFD codes. An example is given to demonstrate the capabilities of the design techniques.
Author

A88-15676
IMPULSE WIND TUNNELS [IMPUL'SNYE AERODINAMICHESKIE TRUBY]
VLADLEN VLADIMIROVIC ZATOLOKA Novosibirsk, Izdatel'stvo Nauka, 1986, 144 p. In Russian. refs

The efficiency of using impulse wind tunnels for high-Reynolds-number flows is examined with reference to experimental data. It is shown that the compact size of the forechamber and the low quasi-stationarity of this type of wind tunnels makes it possible to produce, over the full Mach range (from transonic to high hypersonic), flow conditions that are practically unattainable in other wind tunnels. In addition, the impulse wind tunnels are much more compact and relatively inexpensive.
V.L.

A88-15701#
NEWTONIAN THEORY FOR THE COMPRESSION SURFACE OF AIRFOILS AT MODERATE OR LARGE INCIDENCE
HAMDI T. HEMDAN (King Saud University, Riyadh, Saudi Arabia) AIAA Journal (ISSN 0001-1452), vol. 25, Oct. 1987, p. 1281-1285. Research supported by King Saud University. refs

This paper considers the problem of steady Newtonian flow over the compression surface of sharp-edged, two-dimensional thin airfoils at moderate or large angles of attack. By combining the Newtonian limits gamma goes to 1 and freestream Mach number goes to infinity (where gamma is the ratio of the specific heats of the gas) with a geometric limiting process in which the wing thickness approaches zero, a system of approximate equations giving a first-order correction to the Newtonian flow is found. The equations are solved in closed form, and a simple formula for the coefficient of surface pressure is obtained. The formula shows the effects of nonzero (gamma - 1) and finite values of the freestream Mach number as well as the surface curvature and angle of attack. Results are presented for several airfoils at various flow parameters.
Author

A88-15702#
USE OF CONFORMAL MAPPING IN GRID GENERATION FOR COMPLEX THREE-DIMENSIONAL CONFIGURATIONS
N. D. HALSEY (Douglas Aircraft Co., Long Beach, CA) AIAA Journal (ISSN 0001-1452), vol. 25, Oct. 1987, p. 1286-1291. Research sponsored by the McDonnell Douglas Independent Research and Development Program. Previously cited in issue 07, p. 836, Accession no. A86-19908. refs

A88-15703#
BLOCK-STRUCTURED SOLUTION SCHEME FOR ANALYZING THREE-DIMENSIONAL TRANSONIC POTENTIAL FLOWS
AKIN ECER and JOHN T. SPYROPOULOS (Purdue University, Indianapolis, IN) AIAA Journal (ISSN 0001-1452), vol. 25, Oct. 1987, p. 1292-1300. Previously cited in issue 07, p. 836, Accession no. A86-19919. refs
(Contract F49620-83-K-0034)

A88-15708*# Rutgers Univ., New Brunswick, N. J.
STRUCTURE OF SUPERSONIC TURBULENT FLOW PAST A SHARP FIN
DOYLE D. KNIGHT (Rutgers University, New Brunswick, NJ), C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA), SEYMOUR BOGDONOFF (Princeton University, NJ), and BRIAN SHAPEY AIAA Journal (ISSN 0001-1452), vol. 25, Oct. 1987, p. 1331-1337. NASA-supported research. refs
(Contract AF-AFOSR-82-0040)

The three-dimensional shock-wave/turbulent-boundary-layer interaction generated by a sharp fin is examined both experimentally and theoretically at Mach 3 for a fin angle 20 deg and Reynolds number 900,000. This study represents an extension of previous research for the sharp fin configuration to stronger interactions. The experimental data include surface pressure profiles, surface streamline patterns, and boundary-layer profiles of pitot pressure and yaw angle. Two separate theoretical approaches or 'models' were employed. Both models utilize the three-dimensional compressible Navier-Stokes equations in mass-averaged variables. The theoretical approach of Knight (1984 and 1985) employs the algebraic turbulent eddy-viscosity model of Baldwin and Lomax (1978), and the theoretical model of Horstman (1984) employs the two-equation turbulence model of Jones and Launder (1972) coupled with the wall function model of Viegas et al. (1985).
Author

A88-15710#
VISCOUS-INVISCID ANALYSIS OF TRANSONIC AND LOW REYNOLDS NUMBER AIRFOILS
MARK DRELA and MICHAEL B. GILES (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452), vol. 25, Oct. 1987, p. 1347-1355. Previously cited in issue 17, p. 2461, Accession no. A86-37816. refs
(Contract F49620-78-C-0084)

A88-15717*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AERODYNAMIC EFFECTS OF DISTRIBUTED SPANWISE BLOWING ON A FIGHTER CONFIGURATION
JARRETT K. HUFFMAN, DAVID E. HAHNE (NASA, Langley Research Center, Hampton, VA), and THOMAS D. JOHNSON, JR. (PRC Kentron, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Oct. 1987, p. 673-679. Previously cited in issue 20, p. 2845, Accession no. A84-41347. refs

A88-15718#
LIFT-CURVE CHARACTERISTICS FOR AN AIRFOIL PITCHING AT CONSTANT RATE
E. J. JUMPER, S. J. SCHRECK, and R. L. DIMMICK (USAF, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 24, Oct. 1987, p. 680-687. Previously cited in issue 07, p. 830, Accession no. A86-19698. refs

A88-15720#
CONSTANT PRESSURE PANEL METHOD FOR SUPERSONIC UNSTEADY AIRLOAD ANALYSIS
K. APPA (Northrop Corp., Hawthorne, CA) (Structures, Structural Dynamics and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985, Technical Papers. Part 2, p. 50-55) Journal of Aircraft (ISSN 0021-8669), vol. 24, Oct. 1987, p. 696-702. Previously cited in issue 13, p. 1845, Accession no. A85-30325. refs

A88-15721#
PREDICTION OF GUST LOADINGS AND ALLEVIATION AT TRANSONIC SPEEDS
DAVID NIXON and KEH LIH TZUOO (Nielsen Engineering and Research, Inc., Mountain View, CA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Oct. 1987, p. 703-709. Previously cited in issue 24, p. 3534, Accession no. A86-49573. refs
(Contract N00167-83-C-0114)

A88-15722*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TRANSITION ON SWEPT LEADING EDGES AT MACH 3.5
T. R. CREEL, JR., I. E. BECKWITH, and F. J. CHEN (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Oct. 1987, p. 710-717. Previously cited in issue 17, p. 2468, Accession no. A86-38447. refs

A88-16336#
EXPERIMENTAL INVESTIGATION ON LONGITUDINAL CHARACTERISTICS OF THE FORWARD SWEPT WING
YAOBIN GUO, XUEJIAN WANG, and BINJIANG ZHANG (Harbin Aerodynamics Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, June 1987, p. B227-B238. In Chinese, with abstract in English.

The aerodynamic characteristics of forward-swept wings (FSWs) and swept-back wings (SBWs) at subsonic and transonic speeds are investigated experimentally in wind-tunnel tests. The results are presented in extensive tables and graphs and briefly characterized. At lower speeds, the performance of the FSW is shown to be significantly improved by modifying the separation flowfield over the inboard portion of the wing (e.g., by swept-back inboard fairings), and a closed coupled canard configuration with FSW is found to have much better lift/drag properties than the same configuration with an SWB. At Mach 1.1 and angle of attack 6 deg, the lift-induced drag of the FSW is 12.5 percent less than that of the SBW. T.K.

A88-16338#
AERODYNAMIC DESIGN CHARACTERISTIC OF TEST CELL FOR HIGH BY-PASS RATIO TURBOFAN ENGINE
SHAORONG GUO (China Aeronautical Project and Design Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, June 1987, p. B251-B255. In Chinese, with abstract in English.

This article briefly introduces the aerodynamic design characteristics of a test cell for high-bypass-ratio turbofan engines and discusses the extreme importance of keeping a uniform flow distribution in the test cell, with consideration of the construction experience of the 7907 test cell for CAAC. This experience will be very helpful in the design of tests for high-bypass-ratio turbofan and propfan engines. Author

A88-16339#
ANALYSIS OF THE PERFORMANCE OF AERODYNAMICALLY VARIABLE NOZZLE
DA WU and ZHENNING DONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, June 1987, p. B256-B261. In Chinese, with abstract in English. refs

An analytical procedure for computing the performance of exhaust nozzles with aerodynamically variable geometry is presented in this paper. The performance of a scale nozzle model is calculated by using this method and compared (in terms of thrust coefficient, pumping characteristics, and area-ratio variation) with the data obtained from scale nozzle model tests. The reuslts of this comparison indicate good agreement. Author

A88-16341#
COMPUTATION OF THE COMPENSATION PITOT TUBE IN FRONT OF THE NOSE INLET OF AN AIRCRAFT AT TRANSONIC SPEED
YUN BAO and SHIJUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, June 1987, p. B287-B290. In Chinese, with abstract in English. refs

The aerodynamically compensating pitot tube, which is used to reduce the error of an aircraft pressure altimeter, is studied by the mixed difference computation of small transonic disturbances. The static pressure distribution of the compensating pitot tube and the positive pressure field in front of the nose inlet are calculated. The static pressure error produced by the nose inlet is compensated by the negative pressure at the static pressure orifice of the pitot tube. The computed results and prediction agree very well with wind-tunnel and flight test data. Author

A88-16442#
NUMERICAL SIMULATION OF TWO-DIMENSIONAL TRANSONIC FLOW OVER THIN OSCILLATING AIRFOIL
KAREL KOZEL and MIROSLAVA VAVRINCOVA Zprava VZLU, no. Z-51, 1986, p. 1-10. refs

Calculations of the two-dimensional transonic flow over an oscillating, thin airfoil in a channel using the finite-difference method and the original semiimplicit difference scheme are presented. The results demonstrate the suitability of both methods. The finite difference method yields results identical to the semiimplicit difference scheme for low values of the coefficient of reduced frequency as well as for higher and very high ones. The case of an unsteady flow over an oscillating airfoil for a simultaneous time variation of the velocity of the uniform parallel inlet flow is also considered. The finite difference method is suitable for use on available computers. C.D.

A88-16443
NUMERICAL SOLUTION OF FLOW OF IDEAL FLUID THROUGH CASCADE IN A PLANE
JAROSLAV PELANT Zprava VZLU, no. Z-52, 1987, p. 1-12.

The main purpose of the paper is to describe the numerical method for a flow of an ideal fluid through a cascade in a plane using Euler's equations rewritten into the integral form. The validity of the matter, energy, and momentum conservation laws is assumed. The integral form admits of discontinuities in velocity, pressure, and density. The method can do without prior definition of the subsonic and supersonic regions and it is based on the disintegration of the discontinuities in state values in the net of the region concerned. Author

A88-16446
NUMERICAL SOLUTION OF NON-STATIONARY THREE-DIMENSIONAL TRANSONIC FLOW OVER A THIN BODY
KAREL KOZEL and MIROSLAVA VAVRINCOVA Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1987, p. 179-183. In Czech. refs

The paper deals with a numerical solution of an unsteady three-dimensional transonic flow over a thin body in a wind tunnel of rectangular cross section. The problem is described by an unsteady equation of a low disturbance potential. A weak solution considering ocurrence of shock waves is defined by applying a conservative form of the basic equation. The problem is solved by applying the method of finite differences with the original semiimplicit difference scheme. Author

A88-16567*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONTROL OF SHEAR FLOWS BY ARTIFICIAL EXCITATION
E. J. RICE and K. B. M. Q. ZAMAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 11 p. Previously announced in STAR as N87-29420. refs
(AIAA PAPER 87-2722)

Investigations involving artificial excitation of various shear flows are reviewed. Potential applications of excitation in flow control, e.g., in enhancing mixing, and in delaying transition and separation are discussed. An account is given of the current activities at NASA Lewis Research Center in this regard. Author

A88-16852
NUMERICAL STUDIES ON RAREFIED FLOW OVER A FLAT PLATE AT AN ANGLE OF ATTACK
E. M. SHAKHOV (AN SSSR, Vychislitel'nyi Tsentr, Moscow, USSR) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 1 . Stuttgart, B. G. Teubner, 1986, p. 482-491. refs

The numerical results on supersonic flow over a plate are based on a kinetic model. A finite difference method is employed. For the plate at zero incidence, the flow-over can be treated as hypersonic one as Mach number M is greater than about 5. The flow fields and the behavior of the aerodynamical characteristics are discussed for M = 5-10 and the Knudsen numbers from the range of Km between 0.4 and infinity. The results are compared with the available experimental and computational data. As a conclusion, the effect of finite thickness and the influence of possible weak divergence of the stream on the aerodynamical coefficients are discussed. Author

A88-16857
SLIP EFFECTS ON SUPERSONIC FLOWFIELDS AROUND NACA 0012 AIRFOILS
J. ALLEGRE, M. RAFFIN (CNRS, Laboratoire d'Aerothermique, Meudon, France), and L. GOTTESDIENER (Paris VI, Universite; CNRS, Laboratoire d'Aerothermique, Meudon, France) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 1 . Stuttgart, B. G. Teubner, 1986, p. 548-557. DRET-supported research. refs

The present investigation concerns flowfields around NACA 0012 airfoils located at zero angle of attack in a supersonic air stream characterized by a Mach number of 2 and a Reynolds number of 106 as based on the airfoil chord. Experimental density and velocity flowfields are compared with theoretical distributions calculated by solving Navier Stokes equations. Significant differences are shown between experimental and predicted values when no slip conditions are taken into account in the theory. Differences are considerably reduced when slip velocity and wall temperature jump are introduced in the theory. Author

A88-16861
AN IMPROVED STAGNATION POINT VISCOUS SHOCK LAYER FLOW OVER A BLUNT BODY
A. C. JAIN (Indian Institute of Technology, Kanpur, India) and PRADEEP KUMAR (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandrum, India) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 1 . Stuttgart, B. G. Teubner, 1986, p. 597-606. refs

A new solution for the stagnation point viscous shock layer is presented which incorporates the effect of the stagnation point shock curvature. Governing equations for the leading terms are derived from the full Navier-Stokes equations and solved using surface slip and shock slip conditions consistent with the Navier-Stokes equations. Numerical solutions for a wide range of prescribed conditions are compared with available theoretical investigations and experimental data. It is noted that the new stagnation point viscous shock layer description has a greatly improved prediction capability in the low Reynolds number regime. V.L.

A88-16863
UPPER ATMOSPHERE AERODYNAMICS - MATHEMATICAL MODELLING AND EXPERIMENT VALIDATION
M. PANDOLFI and M. G. ZAVATTARO (Torino, Politecnico, Turin, Italy) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 1 . Stuttgart, B. G. Teubner, 1986, p. 618-626. Research supported by the Ministero della Pubblica Istruzione. refs

This paper provides an analysis of the hard-cubes mathematical model for the analysis of two-dimensional aerodynamics in rarefied flow conditions. The theoretical results are compared with experimental ones realized in hypersonic wind tunnels and are discussed as a mathematical model for upper atmosphere aerodynamics. Author

A88-16875* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A CONTINUUM ANALYSIS OF CHEMICAL NONEQUILIBRIUM UNDER HYPERSONIC LOW-DENSITY FLIGHT CONDITIONS
R. N. GUPTA (NASA, Langley Research Center, Hampton, VA) IN: International Symposium on Rarefied Gas Dynamics, 15th, Grado, Italy, June 16-20, 1986, Proceedings. Volume 2 . Stuttgart, B. G. Teubner, 1986, p. 432-441. refs

Results of employing the continuum model of Navier-Stokes equations under the low-density flight conditions are presented. These results are obtained with chemical nonequilibrium and multicomponent surface slip boundary conditions. The conditions analyzed are those encountered by the nose region of the Space Shuttle Orbiter during reentry. A detailed comparison of the Navier-Stokes (NS) results is made with the viscous shock-layer (VSL) and direct simulation Monte Carlo (DSMC) predictions. With the inclusion of new surface-slip boundary conditions in NS calculations, the surface heat transfer and other flowfield quantities adjacent to the surface are predicted favorably with the DSMC calculations from 75 km to 115 km in altitude. This suggests a much wider practical range for the applicability of Navier-Stokes solutions than previously thought. This is appealing because the continuum (NS and VSL) methods are commonly used to solve the fluid flow problems and are less demanding in terms of computer resource requirements than the noncontinuum (DSMC) methods. Author

N88-11629# Naval Postgraduate School, Monterey, Calif.
A HEAT TRANSFER MODEL FOR A HEATED HELIUM AIRSHIP M.S. Thesis
RAY M. RAPERT Mar. 1987 85 p
(AD-A183786) Avail: NTIS HC A05/MF A01 CSCL 01A

Basic heat transfer empirical and analytical equations are applied to a double envelope airship concept which uses heated helium in the inner envelope to augment and/or control gross lift. The convective and conductive terms lead to a linear system of five equations for the concept airship, with the nonlinear radiation terms included by an iterative solution process. A FORTRAN program, is used to perform the tedious calculations, and graphed results are obtained for the variables of interest. These indicate that the simple use of airship engine exhaust heat will give more than a 30 percent increase in gross airship lift. Possibly more than 100 percent increase can be achieved if a steam injection heating system, with associated design problems, is used. GRA

N88-11631# European Space Agency, Paris (France).
A SUPERSONIC POTENTIAL GRADIENT METHOD FOR THE CALCULATION OF UNSTEADY AERODYNAMIC PRESSURES ON HARMONICALLY OSCILLATING WINGS
FUQING ZHANG Sep. 1987 117 p Transl. into ENGLISH of Ein Supersonisches Potentialgradienten-Verfahren zur Berechnung der Instationaeren Luftkraefte Harmonisch Schwingender Traegflaechen (Goettingen, Federal Republic of Germany) Original language document was announced as N85-31026
(ESA-TT-930; DFVLR-FB-86-11; ETN-87-91109) Avail: NTIS HC A06/MF A01; original German version available from DFVLR, Cologne, Federal Republic of Germany

A method for calculating unsteady aerodynamic pressure distribution on harmonically oscillating three-dimensional wings in supersonic flow based on the velocity potential, the Jones-Appa gradient method, and on the application of an integral variable substitution to evaluate the aerodynamic influence function was developed. The method simplifies the computation and reduces computing time at low supersonic Mach numbers and high reduced frequencies. Investigations on typical wing configurations confirm accuracy. ESA

N88-11633# European Space Agency, Paris (France).
ON THE PREDICTION OF THE AEROELASTIC BEHAVIOR OF LIFTING SYSTEMS DUE TO FLOW SEPARATION
HARTMUT ZINGEL Sep. 1987 166 p Transl. into ENGLISH of Zur Bestimmung des Aeroelastischen Verhaltens von Auftriebssystemen Infolge von Stroemungsabloesung (Goettingen, Federal Republic of Germany) Original language document was previously announced as N87-17685
(ESA-TT-1043; DFVLR-FB-86-35; ETN-87-91118) Avail: NTIS HC A08/MF A01; original German version available from DFVLR, Cologne, Federal Republic of Germany DM 51.50

The prediction of structural vibrations on the basis of linear equations of motion is described for the case of a trapezoidal wing model. The unsteady aerodynamic quantities are determined in wind tunnel experiments. The dynamic response behavior at separated flow measured on a freely vibrating model in a wind tunnel was approximated by a calculated prediction. For coupled vibrations, simplified equations of motion can be used. ESA

N88-11634# European Space Agency, Paris (France).
INVESTIGATIONS ON A TRANSONIC AIRFOIL WITH A 30 MM WIDE PERFORATION/CAVITY ARRANGEMENT
PAUL KROGMANN Sep. 1987 49 p Transl. into ENGLISH of Untersuchungen an einem Transsonischen Profil mit 30 mm Breiter Perforation/Kammer-Anordnung (Goettingen, Fed. Republic of Germany, DFVLR), Nov. 1986 Original language document was announced as N87-28506
(ESA-TT-1072; DFVLR-FB-86-59; ETN-87-91131) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne, Fed. Republic of Germany DM 16

Pressure distribution and wake measurements were carried out in a 1m x 1m transonic wind tunnel on a two-dimensional supercritical airfoil equipped with a perforated strip and a cavity underneath. Compared with reference measurements on the same model with a solid surface, the results of the model with the perforation/cavity arrangement at supercritical flow conditions show a substantial increase of the maximum lift and especially strong drag reductions. These aerodynamic improvements are related to the very favorable effect of the passive secondary flow through the perforation and cavity, induced by strong adverse pressure gradients in this region. The detrimental effects of the passive device on the aerodynamic characteristics of the airfoil at subcritical flow are negligible. ESA

N88-11636*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A CRITICAL ASSESSMENT OF WIND TUNNEL RESULTS FOR THE NACA 0012 AIRFOIL
W. J. MCCROSKEY Oct. 1987 24 p Presented at the AGARD Fluid Dynamics Panel Symposium on Aerodynamic Data Accuracy and Quality: Requirements and Capabilities in Wind Tunnel Testing, Naples, Italy, 28 Sep. - 2 Oct. 1987
(NASA-TM-100019; A-87321; NAS 1.15:100019; USAAVSCOM-TM-87-A-5) Avail: NTIS HC A03/MF A01 CSCL 01A

A large body of experimental results, obtained in more than 40 wind tunnels on a single, well-known two-dimensional configuration, has been critically examined and correlated. An assessment of some of the possible sources of error has been made for each facility, and data which are suspect have been identified. It was found that no single experiment provided a complete set of reliable data, although one investigation stands out as superior in many respects. However, from the aggregate of data the representative properties of the NACA 0012 airfoil can be identified with reasonable confidence over wide ranges of Mach number, Reynolds number, and angles of attack. This synthesized information can now be used to assess and validate existing and future wind tunnel results and to evaluate advanced Computational Fluid Dynamics codes. Author

N88-11640*# Sikorsky Aircraft, Stratford, Conn.
AN EXPERIMENTAL EVALUATION OF ADVANCED ROTORCRAFT AIRFOILS IN THE NASA AMES ELEVEN-FOOT TRANSONIC WIND TUNNEL Contractor Report, Mar. 1982 - Apr. 1983
ROBERT J. FLEMMING Sep. 1984 162 p
(Contract MOA-14800-039)
(NASA-CR-166587; NAS 1.26:166587; SER-510106) Avail: NTIS HC A08/MF A01 CSCL 01A

Five full scale rotorcraft airfoils were tested in the NASA Ames Eleven-Foot Transonic Wind Tunnel for full scale Reynolds numbers at Mach numbers from 0.3 to 1.07. The models, which spanned the tunnel from floor to ceiling, included two modern baseline airfoils, the SC1095 and SC1094 R8, which have been previously tested in other facilities. Three advanced transonic airfoils, designated the SSC-A09, SSC-A07, and SSC-B08, were tested to confirm predicted performance and provide confirmation of advanced airfoil design methods. The test showed that the eleven-foot tunnel is suited to two-dimensional airfoil testing. Maximum lift coefficients, drag coefficients, pitching moments, and pressure coefficient distributions are presented. The airfoil analysis codes agreed well with the data, with the Grumman GRUMFOIL code giving the best overall performance correlation. M.G.

N88-12454*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PLANFORM EFFECTS ON THE SUPERSONIC AERODYNAMICS OF MULTIBODY CONFIGURATIONS
NAOMI MCMILLIN and RICHARD M. WOOD 1987 138 p
(NASA-TP-2762; L-16312; NAS 1.60:2762) Avail: NTIS HC A07/MF A01 CSCL 01A

An experimental and theoretical investigation of the effect of planform on the supersonic aerodynamics of low-fineness-ratio multibody configurations was conducted. Longitudinal and lateral-directional aerodynamic and flow visualization data were obtained on three multibody configurations. The data indicated that planform has a small effect on the zero lift drag of a multibody configuration. The longitudinal data obtained at lifting conditions showed a sensitivity to planform shape. Lateral-directional data obtained for all configurations did not uncover any unusual stability traits for this class of configuration. A comparison study was also made between the planform effects observed on single-body and multibody configurations. Results from this study indicate that the multibody concept appears to offer a mechanism for employing a low-sweep wing with no significant increase in zero-lift drag but still retaining high-performance characteristics at high-lift conditions. Evaluation of the linear-theory prediction methods revealed a

general inability of the methods to predict the characteristics of low-fineness-ratio geometries. Author

N88-12455* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF JET EXHAUST YAW VANE INSTALLATION AND OPERATION ON THE LONGITUDIANL AND LATERAL-DIRECTIONAL CHARACTERISTICS OF THE F-14 AIRPLANE
DAVID E. REUBUSH and BOBBY L. BERRIER Dec. 1987
121 p
(NASA-TP-2769; L-16302; NAS 1.60:2769) Avail: NTIS HC A06/MF A01 CSCL 01A

A wind tunnel investigation was conducted in the Langley 16-Foot Transonic Tunnel to determine the effects of the installation and use of jet exhaust yaw vanes on the longitudinal and lateral-directional characteristics of the F-14 aircraft. The model was tested at Mach numbers from 0.70 to 1.25 at angles of attack from 0 deg to 4.3 deg. Compressed air was used to simulate nozzle exhaust flow from jet off up to a nozzle pressure ratio of 8. The results of the investigation show that the yaw vanes can augment the rudders to provide directional control, but further investigation will be necessary to optimize the deflection schedule associated with the various nozzle power settings. Author

N88-12456* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SEMIEMPIRICAL METHOD FOR PREDICTION OF AERODYNAMIC FORCES AND MOMENTS ON A STEADILY SPINNING LIGHT AIRPLANE
BANDU N. PAMADI (Vigyan Research Associates, Inc., Hampton, Va.) and LAWRENCE W. TAYLOR, JR. Dec. 1987 89 p
(NASA-TM-4009; L-15654; NAS 1.15:4009) Avail: NTIS HC A05/MF A01 CSCL 01A

A semi-empirical method is presented for the estimation of aerodynamic forces and moments acting on a steadily spinning (rotating) light airplane. The airplane is divided into wing, body, and tail surfaces. The effect of power is ignored. The strip theory is employed for each component of the spinning airplane to determine its contribution to the total aerodynamic coefficients. Then, increments to some of the coefficients which account for centrifugal effect are estimated. The results are compared to spin tunnel rotary balance test data. Author

N88-12457*# Vigyan Research Associates, Inc., Hampton, Va.
THE DESIGN AND PRELIMINARY CALIBRATION OF A BOUNDARY-LAYER FLOW CHANNEL
DHANVADA M. RAO and TIMMY T. KARIYA (George Washington Univ., Washington, D.C.) Oct. 1987 37 p
(Contract NAS1-17919; NCC1-24)
(NASA-CR-178399; NAS 1.26:178399) Avail: NTIS HC A03/MF A01 CSCL 01A

Design procedures for a new low-speed boundary-layer research channel are described. The channel is an open-circuit wind tunnel for the study of two-dimensional boundary layers under controlled pressure gradients, and follows design guidelines from published literature on blower tunnels with wide-angle diffusers. The contraction was arranged in a modular fashion permitting two different test sections of square and high-aspect-ratio cross section. A radical type of wide-angle diffuser was employed, and a stream-tube computer code (GE Streamtube Curvature Code) was used to check the contraction designs. The alternate test sections have the following specifications: 2- by 2-foot cross section with a fixed velocity of 23 ft/sec, and a boundary-layer section with a 0.5- by 2-foot cross section at a fixed velocity of approximately 89 ft/sec. Experimental techniques and data are described for the evaluation of diffuser effectiveness, boundary-layer channel characteristics, and overall performance of the facility. Author

N88-12458*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
AN EXPERIMENTAL INVESTIGATION OF DYNAMIC GROUND EFFECT Final Report
PAI HUNG LEE, C. EDWARD LAN, and VINCENT U. MUIRHEAD Washington Dec. 1987 85 p
(Contract NAG1-616)
(NASA-CR-4105; NAS 1.26:4105; CRING-FRL-717-1) Avail: NTIS HC A05/MF A01 CSCL 01A

A 60-degree delta wing, an F-106B, and an XB-70 model with and without flap deflections were tested in static and dynamic ground effect in the 36-by 51-inch subsonic wind tunnel at the University of Kansas. Dynamic ground effect was measured with movable sting support. For flow visualization, a tufted wire grid was mounted on the movable sting behind the model. Test results showed that lift and drag increments in dynamic ground effect were always lower than static values. Effect of the trailing edge flap deflections on lift increments was slight. The fuselage reduced the lift increments at a given ground height. From flow visualization under static conditions, the vortex core was seen to enlarge as the ground was approached. Author

N88-12459*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AERODYNAMIC SENSITIVITIES FROM SUBSONIC, SONIC AND SUPERSONIC UNSTEADY, NONPLANAR LIFTING-SURFACE THEORY
E. CARSON YATES, JR. Sep. 1987 18 p
(NASA-TM-100502; NAS 1.15:100502) Avail: NTIS HC A03/MF A01 CSCL 01A

The technique of implicit differentiation has been used in combination with linearized lifting-surface theory to derive analytical expressions for aerodynamic sensitivities (i.e., rates of change of lifting pressures with respect to general changes in aircraft geometry, including planform variations) for steady or oscillating planar or nonplanar lifting surfaces in subsonic, sonic, or supersonic flow. The geometric perturbation is defined in terms of a single variable, and the user need only provide simple expressions or similar means for defining the continuous or discontinuous global or local perturbation of interest. Example expressions are given for perturbations of the sweep, taper, and aspect ratio of a wing with trapezoidal semispan planform. In addition to direct computational use, the analytical method presented here should provide benchmark criteria for assessing the accuracy of aerodynamic sensitivities obtained by approximate methods such as finite geometry perturbation and differencing. The present process appears to be readily adaptable to more general surface-panel methods. Author

N88-12460 Georgia Inst. of Tech., Atlanta.
A METHOD FOR THE EFFICIENT CALCULATION OF ELASTIC ROTOR BLADE DYNAMIC RESPONSE IN FORWARD FLIGHT Ph.D. Thesis
DANA JAMES TAYLOR 1987 188 p
Avail: Univ. Microfilms Order No. DA8715823

A comprehensive set on nonlinear, integro-partial differential equations of motion are developed for an elastic rotor blade with nonuniform structural, geometric and aerodynamic properties, and chordwise offsets with flap, lag, and torsional degrees of freedom. The structural dynamic formulation parallels that derived by Hodges and Dowell and is extended for forward flight. The aerodynamic formulation parallels the development presented by Kaza and Kvaternik and is extended to consider linear inflow and unsteady aerodynamic approximations. The governing equations are solved in an efficient manner utilizing a modified Galerkin-generalized harmonic balance approach. Incorporated into the solution method is the capability of considering the elastic deformation of the rotor blade while calculating the control inputs. Results are presented which represent the response, shown in terms of nondimensional tip displacement as well as root loads, of an isolated articulated rotor whose blades possess nonuniform properties and chordwise offsets. The flight conditions considered are hover and forward flight at mu = 0.2 and m = 0.4. The quantitative effects of

unsteady aerodynamics, linear inflow, and elastic trim are shown. It is concluded that the consideration of unsteady aerodynamics, nonuniform inflow and blade elasticity when calculating trim is dependent on the final use of the response. Dissert. Abstr.

N88-12461*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
APPLICATION OF RUNGE KUTTA TIME MARCHING SCHEME FOR THE COMPUTATION OF TRANSONIC FLOWS IN TURBOMACHINES
S. V. SUBRAMANIAN and R. BOZZOLA (Avco Lycoming Div., Stratford, Conn.) 1987 19 p Presented at the 21st Joint Propulsion Conference, Monterey, Calif., 8-10 Jul. 1985; sponsored by AIAA, SAE and ASME Previously announced in IAA as A85-39728
(NASA-TM-86997; E-2543; NAS 1.15:86997) Avail: NTIS HC A03/MF A01 CSCL 01A

Numerical solutions of the unsteady Euler equations are obtained using the classical fourth order Runge Kutta time marching scheme. This method is fully explicit and is applied to the governing equations in the finite volume, conservation law form. In order to determine the efficiency of this scheme for solving turbomachinery flows, steady blade-to-blade solutions are obtained for compressor and turbine cascades under subsonic and transonic flow conditions. Computed results are compared with other numerical methods and wind tunnel measurements. The study also focuses on other important numerical aspects influencing the performance of the algorithm and the solution accuracy such as grid types, boundary conditions and artificial viscosity. For this purpose, H, O, and C type computational grids as well as characteristic and extrapolation type boundary conditions are included in solution procedures. Author

N88-12462*# Textron Bell Helicopter, Fort Worth, Tex.
A 0.15-SCALE STUDY OF CONFIGURATION EFFECTS ON THE AERODYNAMIC INTERACTION BETWEEN MAIN ROTOR AND FUSELAGE
TED TREPT Jan. 1984 634 p
(Contract NAS2-11268)
(NASA-CR-166577; NAS 1.26:166577) Avail: NTIS HC A99/MF A01 CSCL 01A

Hover and forward flight tests were conducted to investigate the mutual aerodynamic interaction between the main motor and fuselage of a conventional helicopter configuration. A 0.15-scale Model 222 two-bladed teetering rotor was combined with a 0.15-scale model of the NASA Ames 40x80-foot wind tunnel 1500 horsepower test stand fairing. Configuration effects were studied by modifying the fairing to simulate a typical helicopter forebody. Separation distance between rotor and body were also investigated. Rotor and fuselage force and moment as well as pressure data are presented in graphical and tabular format. Data was taken over a range of thrust coefficients from 0.002 to 0.007. In forward flight speed ratio was varied from 0.1 to 0.3 with shaft angle varying from +4 to -12 deg. The data show that the rotors effect on the fuselage may be considerably more important to total aircraft performance than the effect of the fuselage on the rotor. Author

N88-12464# Sandia National Labs., Albuquerque, N. Mex.
THE AERODYNAMICS OF SUPERSONIC PARACHUTES
C. W. PETERSON Jun. 1987 29 p Presented at the Parachute Systems Technology: Fundamentals, Concepts, and Applications, Munich, Fed. Republic of Germany, 22 Jun. 1987
(Contract DE-AC04-76DP-00789)
(DE87-014846; SAND-87-1395C; CONF-8706165-3) Avail: NTIS HC A03/MF A01

A discussion of the aerodynamics and performance of parachutes flying at supersonic speeds is the focus of this paper. Typical performance requirements for supersonic parachute systems are presented, followed by a review of the literature on supersonic parachute configurations and their drag characteristics. Data from a recent supersonic wind tunnel test series is summarized. The value and limitations of supersonic wind tunnel data on hemisflo and 20-degree conical ribbon parachutes behind several forebody shapes and diameters are discussed. Test techniques were derived which avoided many of the opportunities to obtain erroneous supersonic parachute drag data in wind tunnels. Preliminary correlations of supersonic parachute drag with Mach number, forebody shape and diameter, canopy porosity, inflated canopy diameter and stability are presented. Supersonic parachute design considerations are discussed and applied to a M = 2 parachute system designed and tested at Sandia. It is shown that the performance of parachutes in supersonic flows is a strong function of parachute design parameters and their interactions with the payload wake. DOE

N88-12465*# Eloret Corp., Sunnyvale, Calif.
DEVELOPMENT AND APPLICATION OF COMPUTATIONAL AEROTHERMODYNAMICS FLOWFIELD COMPUTER CODES Technical Progress Report, 1 Sep. 1986 - 31 Oct. 1987
ETHIRAJ VENKATAPATHY 9 Dec. 1987 29 p
(Contract NCC2-420)
(NASA-CR-181534; NAS 1.26:181534) Avail: NTIS HC A03/MF A01 CSCL 01A

Multiple nozzle plume flow field is computed with a 3-D, Navier-Stokes solver. Numerical simulation is performed with a flux-split, two-factor, time asymptotic viscous flow solver of Ying and Steger. The two factor splitting provides a stable 3-D solution procedure under ideal-gas assumptions. An ad-hoc acceleration procedure that shows promise in improving the convergence rate by a factor of three for steady state problems is utilized. Computed solutions to generic problems at various altitude and flight conditions show flow field complexity and three-dimensional effects due to multiple nozzle jet interactions. Viscous, ideal gas solutions for the symmetric nozzle are compared with other numerical solutions. Author

N88-12468 Colorado Univ., Boulder.
THREE-DIMENSIONAL UNSTEADY FLOW ELICITED BY FINITE WINGS AND COMPLEX CONFIGURATIONS Ph.D. Thesis
JEFFREY CLAYTON ASHWORTH 1987 191 p
Avail: Univ. Microfilms Order No. DA8716236

The spatial and temporal transport, accumulation and dissipation of vorticity on the surface of 3 wings varying only in sweep angles were examined using flow visualization and hot wire anemometry. Identical geometric positions were tested on each wing for a variety of dynamic parameters. Each sweep geometry produced distinct, time dependent, spanwise and chordwise sites for vorticity accumulation into large scale leading edge and wingtip vortices. The wingtip and leading edge vortex interactions produced spanwise flow patterns uncharacteristic of 2 dimensional flows. Wing sweep is a dominant geometric parameter in analyzing the effects of unsteady wingtip flow. An initial investigation into the feasibility of unsteady flow application was performed on a model of the X-29 Forward Swept Wing Technology Demonstrator. This model geometry produces complex flow patterns but may be ideally suited for application of unsteady flow technology. These investigations provide initial insight into 3 dimensional flow behavior elicited by different sweep geometries and dynamic parameters. Dissert. Abstr.

N88-12469 Princeton Univ., N. J.
SOLUTION OF THE TWO-DIMENSIONAL EULER EQUATIONS ON UNSTRUCTURED TRIANGULAR MESHES Ph.D. Thesis
DIMITRI JAMES MAVRIPLIS 1987 157 p
Avail: Univ. Microfilms Order No. DA8716898

Solutions of inviscid subsonic and transonic flows about multi-element airfoils are obtained using two-dimensional Euler equations. An edge-based data structure is adopted, where the simplest element of the mesh is taken as the edge rather than the triangular element itself. Two finite-volume discretization schemes are developed, one where the flow variables are stored at the center of each triangular element, and the other where the flow variables are stored at the vertices of the triangles. Convergence to a steady state is accelerated by local time-stepping, enthalpy-damping, and implicit residual-averaging. A novel multigrid algorithm for use on a sequence of completely

unstructured, unrelated meshes is also developed. Solutions of both Euler schemes are compared to a variety of numerical results and experimental data and are found to exhibit similar accuracy to other existing Euler solvers. However, it was found that viscous effects on multi-element airfoils are most often non-negligible, e.g., drag is underpredicted by 10 to 15 percent for a particular case involving small regions of viscous flow. The use of unstructured meshes was found to result in substantially higher memory and CPU time requirements due to the indirect addressing needed and the use of shorter vector lengths. On the other hand, they enable the solution of the flow about arbitrarily shaped two-dimensional bodies. Dissert. Abstr.

N88-12628# Joint Publications Research Service, Arlington, Va.
RENEWED INTEREST IN AIRSHIPS FOR INDUSTRY USE DISCUSSED
M. ARIYE *In its* USSR Report: Engineering and Equipment p 61-62 28 May 1987 Transl. into ENGLISH from Stroitelnaya Gazeta (Moscow, USSR), 23 Jan. 1987 p 3
Avail: NTIS HC A06/MF A01

The use and development of airships in the U.S.S.R is discussed. The unique combination of features possessed by these machines (vertical takeoff and landing, large lift capacity, distance and duration of flight, and safety of operation) are noted. The development of a plan for a combined aerostatic airship of a semi-rigid type with a lift capacity of up to 30 tons is discussed. Author

N88-12630# Joint Publications Research Service, Arlington, Va.
CALCULATION OF THREE-DIMENSIONAL STATIONARY TURBULENT BOUNDARY LAYER ON ROOT SECTION OF WING IGNORING COMPRESSIBILITY Abstract Only
G. A. SHCHEKIN *In its* USSR Report: Engineering and Equipment p 89 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 72-76
Avail: NTIS HC A06/MF A01

A method for calculating a three dimensional steady state turbulent boundary layer is proposed. It is based on a general method for calculating three dimensional compressible laminar and turbulent boundary layers on arbitrary wings. Boundary conditions on the surface and on the external boundary of the boundary layer were formulated. In the transition region, the coefficient of turbulent viscosity increases in direct proportion to the longitudinal coefficient of intermittency. After transformations, the initial set of equations was solved numerically using the Petukhov finite differences method. For solving the set of equations on a computer, a computer program, written in FORTRAN, was written. Components of the local coefficient of friction resistence, projected onto the chord and wing span directions, the displacement of thickness of the three dimensional boundary layer, and the boundary of the separation region were calculated. Expressions for calculating these parameters are presented. Author

N88-12631# Joint Publications Research Service, Arlington, Va.
CALCULATION OF AERODYNAMIC CHARACTERISTICS OF THREE-DIMENSIONAL FINITE SPAN WINGS IN POTENTIAL INCOMPRESSIBLE FLOW Abstract Only
S. D. YERMOLENKO and YE. A. RYAGUZOV *In its* USSR Report: Engineering and Equipment p 90 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 43-48
Avail: NTIS HC A06/MF A01

A simpler and less time consuming method for calculating the aerodynamic characteristics of three dimensional finite span wings in potential incompressible flow is given. It is based on the application of the discrete vortex method which earlier proved to be effective in solving two dimensional problems. A non-separating potential incompressible flow was examined under the assumption that the wing surface was specified, wherein the left hand side of the wing was symmetrical to its right hand side, its leading and trailing edges were straight, and its ends were flat and there was no slippage. Wing profile could vary across the span and had a geometric twist. The method for constructing a vortex model was explained. Intensities of vortices were determined. Formulae for reduced flow velocity and static pressure coefficient in reference points were derived. Examples of pressure distribution in the root, end and mid-sections of thick wings, calculated in accordance with the proposed method and the authors' methods were presented. These results were compared to wind tunnel tests of the wings. Design and experimental data were in good agreement. Author

N88-12632# Joint Publications Research Service, Arlington, Va.
SOME ASYMPTOTIC MODES OF TRANSONIC VORTEX FLOW Abstract Only
A. G. KUZMIN *In its* USSR Report: Engineering and Equipment p 91 28 May 1987 Transl. into ENGLISH from Vestnik Leningradskogo Universiteta, Seriya 1: Matematika, Mekhanika, Astronomiya (Leningrad, USSR), no. 2, Apr. 1986 p 61-65 Original language document was announced in IAA as A87-15553
Avail: NTIS HC A06/MF A01

Steady state plane parallel vortex flows of an ideal gas are investigated analytically. In particular, a study is made of the qualitative flow patterns in the vicinity of a point where the sonic line is orthogonal with respect to the velocity vector and in the vicinity of a point on the sonic line where acceleration is equal to zero. Together with the results of Shifrin (1966), the results obtained here provide information on all possible flow patterns near the point where the sonic line is orthogonal to the velocity vector and demonstrate a large variety of possible flow patterns near the zero acceleration point. Author

N88-12633# Joint Publications Research Service, Arlington, Va.
CONICAL WING WITH MAXIMUM LIFT-TO-DRAG RATIO IN SUPERSONIC GAS FLOW Abstract Only
V. I. LAPYGIN and P. V. TRETYAKOV *In its* USSR Report: Engineering and Equipment p 92 28 May 1987 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 3, May - Jun. 1986 p 128-133 Original language document was announced in IAA as A87-10615
Avail: NTIS HC A06/MF A01

A theoretical analysis of conical wings at Mach numbers greater than 2 shows that maximum lift-to-drag ratio is possessed by wings with a flat lower surface. Simple analytical relationships are obtained determining the wing aerodynamic characteristics at angles of attack up to the separation of the bow shock from the leading edges. Author

N88-12635# Joint Publications Research Service, Arlington, Va.
NUMERICAL STUDY OF SUPERSONIC FLOW AROUND BLUNT BODIES WITH EXTENDED NEEDLE NOSE Abstract Only
V. N. KARLOVSKIY and V. I. SAKHAROV *In its* USSR Report: Engineering and Equipment p 93 28 May 1987 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 3, May - Jun. 1986 p 119-127
Avail: NTIS HC A06/MF A01

A method was developed for the calculation of supersonic flow of an ideal gas around axisymmetrical blunted bodies with extended needle noses. A study is made of the flow around a truncated cone with a spherical blunted cylindrical needle as a function of the ratio of needle length to diameter of the end portion of the body and Mach number of the incident stream. Several steady flow modes were obtained, including one with circulation zones in the shock layer and internal shock wave. The installation of a needle in advance of the truncated cone can reduce its resistance by 40 to 50 percent. A full study of the change in drag as a function of ratio of needle length is performed for Mach 3. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A88-13385
THE DEVELOPMENT OF EMERGENCY PARACHUTE SYSTEMS FOR THE VOYAGER WORLD FLIGHT
MANLEY C. BUTLER, JR. (Butler Parachute Systems, Inc., California City, CA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 54-59.

The development of the personnel emergency equipment systems used on the Voyager world flight is described. The parachute systems, flotation equipment, and survival gear are indicated, giving the weight of each. The emergency parachute/survival systems are the lightest and most compact ever built with equivalent function and capability. C.D.

A88-13388
KOCH EMERGENCY EGRESS LIGHTING SYSTEMS FOR ADVERSE OPTICAL CONDITIONS FOR MILITARY AND COMMERCIAL AIRCRAFT AND OTHER APPLICATIONS
H. GERALD GROSS (Wickes Manufacturing Co., H. Koch and Sons Div., Anaheim, CA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 80-87.

A88-13392
AIRCRAFT PASSENGER PROTECTION FROM SMOKE AND FIRE
JOHN S. S. STEWART (Royal Albert Edward Infirmary, Wigan, England) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 112-116. refs

The hazards that onboard smoke and fire present to passengers are reviewed, and methods of minimizing them are discussed. Trials of the Integrated Breathing Requirements Equipment for Air Transport Hazards and Evacuation (IBREATHE) system are described, and the results are reviewed. Hybrid safety systems are addressed, and the cost effectiveness of protection is briefly considered. C.D.

A88-13397
H-46 HELICOPTER EMERGENCY FLOTATION SYSTEM (HEFS)
JOHN J. TYBURSKI and WILLIAM A. MAWHINNEY (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 147-152. refs

The Helicopter Emergency Flotation System (HEFS), developed to provide emergency flotation after a controllable water landing, is described. HEFS will keep a helicopter afloat in an upright attitude with escape hatches above the water level for 10 minutes to permit crew and passenger egress. It will keep the aircraft afloat for three hours to permit aircraft recovery. Design verification test results on the HEFS float and pod are reviewed, as are the results of full-system hulk tests and of inflight testing. Test conditions and corresponding results are listed. C.D.

A88-13403
DEALING WITH THE PROBLEM OF DELAYED EJECTIONS
WILLIAM L. LITTLE (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 212-214.

The Navy's possible short-term solution to the problem of delayed ejections is discussed as well as some long-range plans. Based on a preliminary analysis, the Navy found that the areas of safe escape envelopes, reasons for delayed ejection, and the decision making process offered the biggest potential for immediate improvement. Consideration has been given to the use of simulators, a ground proximity warning system, and a computer system that would prevent the aircraft from descending below a predetermined altitude. K.K.

A88-13408
AN UPDATE ON THE DUAL-STAGE TEST PROCEDURE FOR LOW-COST MEASUREMENT OF PARACHUTE PERFORMANCE
RICHARD W. HUNTER (U.S. Naval Weapons Center, China Lake, CA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 247-249.

The dual-stage test procedure was developed at the Naval Weapons Center (NWC) in 1984 as a low-cost alternative to drop testing from aircraft. The test procedure has undergone considerable evolutionary development during its use. The improvements reported here have greatly increased the versatility and usability of the test procedure, with little or no effect on test costs. The improvements include the development and verification of equipment for measuring riser loads, and improved onboard film and live video coverage of the tests. Author

A88-13410
L.W. SKAD (LIGHT WEIGHT SURVIVAL KIT AIR DROPPABLE) DEVELOPMENT PROGRAM
PETER D. JOHNSON (Irvin Industries Canada, Ltd., Fort Erie) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 260-263.

The L.W. SKAD system has been designed to provide accurate and reliable positioning of two liferafts, which are necessary for the survival of those in distress at sea. The functional L.W. SKAD system contains a tail cone and pilot chute assembly, a main chute assembly, a cutter cord assembly, a raft package 'A' assembly, a drogue and rope coil assembly, a raft package 'B' assembly, and a bulkhead and ejection bag assembly. The use of L.W. SKAD on the Tracker and on the de Havilland Dash 8 and the Canadair Challenger has been considered. K.K.

A88-14261#
MODIFICATION OF VTOL FLIGHT FOR REDUCTION OF HOT GAS INGESTION AND FOREIGN OBJECT DAMAGE
ANDREW B. BAUER (Douglas Aircraft Co., Long Beach, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 8 p. refs
(AIAA PAPER 87-2883)

VTOL lift engine exhausts interfere with takeoff and landing operations by blowing loose ground particles and other debris that can be ingested by the engines with deleterious effects. A large VTOL aircraft configuration is presently used in conjunction with jet experiment correlations to demonstrate the ways in which forward and aft motion can alleviate such particle ingestion problems, in exchange for a field length increase to 300 ft, assuming zero wind. While wind conditions aid these methods in takeoff, they exacerbate the problems encountered in landings. Recommendations for further research are formulated. O.C.

A88-14310
SOME OPERATIONAL ASPECTS RELATED TO PLANNING OF AIRSHIP OPERATIONS IN NEW ZEALAND
MAURICE E. MCGREAL IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 13.1 to 13.14.

A88-14314
THE PASSENGER POTENTIAL OF AIRSHIPS
C. M. SMALL IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 17.1 to 17.8.

An overall evaluation is made of the applicability of airships to such passenger services as short-haul business traffic, charter tours, sightseeing, very long range/nonstop flights, and cable-car functions. The airship offers low capital and operating costs, quietness for both overflown populations and the passengers carried, exceptional safety, and resources for passenger comfort that other types of aircraft cannot provide. Above all, the airship's ability to VTOL and hover renders it capable of reaching remote, rugged terrain and small population centers lacking airstrips, such as may be found on otherwise attractive islands and mountainous regions. O.C.

A88-15587
B-1B AVIONICS SYSTEM SAFETY OVERVIEW AND APPROACH
H. L. ERNST and C. R. TURNER (Boeing Military Airplane Co., Seattle, WA) IN: Aerospace Avionics Equipment and Integration Conference and Exhibit, Phoenix, AZ, Apr. 23, 24, 1986, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 109-132. refs
(SAE PAPER 860854)

This paper presents an overview of the B-1B avionics safety analysis. Nuclear safety and terrain-following flight safety were major concerns. Analyses demonstrate that all safety requirements were met. Extensive coordination with the B-1B System Program Office and the support of major B-1B avionics subcontractors was required. The paper summarizes the nuclear safety effort. It presents significant details of the terrain-following analyses to give insight into the technical and integration challenges. Lessons learned are included. Author

A88-16180#
SAFETY AWARENESS CONTINUITY IN TRANSPORTATION AND SPACE SYSTEMS
JOHN C. MACIDULL (FAA, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p. refs
(IAF PAPER 87-568)

The problem of safety awareness in transportation and space systems is discussed with particular reference to the role of definitions, maintenance and safety throughout the system life, the tools of statistics and accident investigation, and some strategies that can be applied to both space vehicles and earth-bound systems. Both proactive and reactive methods of accident prevention are examined. The discussion is illustrated by naval and commercial aircraft historical data and results of the Space Shuttle Challenger investigation. V.L.

A88-16660
MARITIME MISSIONS USING AN INTEGRATED LTA ROLE
A. SARSONS (LR Vivian Associates, Ltd., Toronto, Canada) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 169-193.

The paper presents a concept for the Canadian defence application of LTA in the Atlantic theater. It outlines a plan to integrate LTA with existing equipment to provide a more comprehensive, cost-effective system for maritime surveillance. Once the concept has been implemented, and a viable system established, carbon copies would be developed for the Pacific theater and other NATO countries with similar needs. Author

A88-16661
AIR WORTHINESS CERTIFICATION IN CANADA
LEO GALVIN (Transport Canada, Ottawa) IN: Lighter Than Air International Conference, Vancouver, Canada, Sept. 18, 19, 1986, Proceedings . Edmonton, Canada, Lighter Than Air International, 1986, p. 211-215.

Domestic and foreign LTA aircraft certification procedures in Canada are discussed. It is stressed that any applicants for Canadian certification should make clear whether they anticipate a U.S. market for the airship in question, and will therefore seek FAA approval in due course. Attention is given to the character and significance of the certification compliance program that must be formulated for each applicant. The basis of certification for foreign country-certified aircraft must be acceptable to the Canadian Department of Transport. O.C.

A88-16735
PASSENGER CABIN SAFETY; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, OCT. 29, 1986
London, Royal Aeronautical Society, 1987, 48 p. For individual items see A88-16736 to A88-16741.

The present conference on passenger cabin safety discusses comparative accident statistics characterizing the year 1985, CAA airworthiness requirements for airliner cabins, noteworthy accident investigation determinations, and safety-related policy formulations by a major British airline. Also discussed are airliner staff training for cabin emergencies, aspects of passenger cabin health and safety, the safety-related services rendered by airline professionals, passenger behavior in aircraft emergencies, and the status of current research efforts in the field of airliner passenger safety. O.C.

A88-16736
ACCIDENT STATISTICS
A. F. TAYLOR (Cranfield Aviation Safety Centre, England) IN: Passenger cabin safety; Proceedings of the Symposium, London, England, Oct. 29, 1986 . London, Royal Aeronautical Society, 1987, p. 1-8. refs

The year of 1985 (which was exceptionally severe for British commercial aviation, with particular reference to the B737 airliner accident at Manchester) is placed in the context of previous years and previous survivable accidents. The B737 accident, although apparently very severe, is judged to have been typical of a survivable, 'on-the-airport' fire accident with no fuselage damage and no fatalities due to impact trauma. The findings and recommendations of the Accidents Investigation Branch will accordingly be relevant not only to this accident but also to a large and important group of other accidents. O.C.

A88-16737
PASSENGER CABIN SAFETY - CAA AIRWORTHINESS REQUIREMENTS
D. V. WARREN (Civil Aviation Authority, Airworthiness Div., London, England) IN: Passenger cabin safety; Proceedings of the Symposium, London, England, Oct. 29, 1986 . London, Royal Aeronautical Society, 1987, p. 9-16.

By definition, cabin safety requirements are concerned with survivable or partially survivable accidents and must take into account both the frailty of the human body and the vagaries of human behavior. The two fields of primary activity addressed are fire suppression and survival (notably including rapid escape), and crash/impact survival (which is primarily concerned with cabin structures). Attention is presently given to the fire resistance of cabin seats and ceiling panels, type III emergency exits, and the formulation of future requirements for smoke hoods, passageways, and the distribution of exits. O.C.

A88-16738
AN AIRLINE PHILOSOPHY TO SAFETY
J. D. LEWRY (British Caledonian Airways, Ltd., Crawley, England) IN: Passenger cabin safety; Proceedings of the Symposium, London, England, Oct. 29, 1986 . London, Royal Aeronautical Society, 1987, p. 17-24.

Passenger cabin safety considerations ensure that cabin emergencies are not caused by poor design or the misuse of cabin facilities, and that passengers and crews have good prospects of survival in case of accidents or incidents. It is also necessary to ensure that equipment and work practices adhere to (the UK's) Health and Safety at Work legislation. Attention is presently given to passenger awareness of safety factors, problems caused by on-cabin baggage, and general human factors considerations. O.C.

A88-16740
PASSENGERS AND PROFESSIONALS - THE SAFETY PARTNERSHIP
N. BLYTHE (Consumers' Association, England) IN: Passenger cabin safety; Proceedings of the Symposium, London, England, Oct. 29, 1986 . London, Royal Aeronautical Society, 1987, p. 46-51.

An evaluation is made of the advantages derivable by airliner safety professionals from the fact of intense passenger concern for cabin safety. A recent survey of passengers' attitudes noted a willingness to experiment with crash impact-absorbing, backward-facing airliner seating. Similar initiatives are suggested to be capable of finding enthusiastic support in such matters as harness-type seat belts, safer cabin disposition of duty-free goods, and the already-topical issue of smoke hoods' adoption as emergency breathing equipment. O.C.

N88-11642 Civil Aviation Authority, London (England).
UK AIRMISS STATISTICS
1987 9 p
(CAP-530; ISBN-0-86039-311-9; ISSN-0951-6301; ETN-87-90963) Avail: Issuing Activity

Airmiss totals (civil and military); commercial air transport airmisses; commercial air transport aircraft involved in airmisses; and commercial air transport airmisses related to flying hours for 1977 to 1986 in United Kingdom airspace are tabulated. ESA

N88-11643*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CIVIL APPLICATIONS OF HIGH-SPEED ROTORCRAFT AND POWERED-LIFT AIRCRAFT CONFIGURATIONS
JAMES A. ALBERS and JOHN ZUK Oct. 1987 28 p Prepared for presentation at the International Powered Lift Conference, Santa Clara, Calif., 7-10 Dec. 1987
(NASA-TM-100035; A-87339; NAS 1.15:100035) Avail: NTIS HC A03/MF A01 CSCL 01C

Advanced subsonic vertical and short takeoff and landing (V/STOL) aircraft configurations offer new transportation options for civil applications. Described is a range of vehicles from low-disk to high-disk loading aircraft, including high-speed rotorcraft, V/STOL aircraft, and short takeoff and landing (STOL) aircraft. The status and advantages of the various configurations are described. Some of these show promise for relieving congestion in high population-density regions and providing transportation opportunities for low population-density regions. Author

N88-11644*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
V/STOL AIRCRAFT CONFIGURATIONS AND OPPORTUNITIES IN THE PACIFIC BASIN
JAMES A. ALBERS and JOHN ZUK Aug. 1987 31 p Presented at the 4th SAE International Pacific Conference on Automotive Engineering, Melbourne, Australia, 1 Dec. 1987
(NASA-TM-100005; A-87278; NAS 1.15:100005) Avail: NTIS HC A03/MF A01 CSCL 01C

Advanced aircraft configurations offer new transportation options for the Pacific Basin. Described is a range of vehicles from low-disk to high-disk loading aircraft, including high-speed rotorcraft, subsonic vertical and short takeoff and landing (V/STOL) aircraft, and subsonic short takeoff and landing (STOL) aircraft. The status and advantages of the various configurations are described. Some of these show promise for satisfying many of the transportation requirements of the Pacific Basin; as such, they could revolutionize short-haul transportation in that region. Author

N88-12473*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL EVIDENCE FOR MODIFYING THE CURRENT PHYSICAL MODEL FOR ICE ACCRETION ON AIRCRAFT SURFACES
W. OLSEN and E. WALKER 1986 47 p Film supplement
(NASA-TM-87184; E-3658; NASA-MPD-1683; NAS 1.15:87184) Avail: NTIS HC A03/MF A01; film supplement number NASA-MPD-1683 available from NASA Lewis Research Center, Phototgraphic and Printing Branch, Cleveland, Ohio CSCL 01C

Closeup movies, still photographs, and other experimental data suggest that the current physical model for ice accretion needs significant modification. At aircraft airspeeds there was no flow of liquid over the surface of the ice after a short initial flow, even at barely subfreezing temperatures. Instead, there were very large stationary drops on the ice surface that lose water from their bottoms by freezing and replenish their liquid by catching the microscopic cloud droplets. This observation disagrees with the existing physical model, which assumes there is a thin liquid film continuously flowing over the ice surface. With no such flow, the freezing-fraction concept of the model fails when a mass balance is performed on the surface water. Rime ice does, as the model predicts, form when the air temperature is low enough to cause the cloud droplets to freeze almost immediately on impact. However, the characteristic shapes of horn-glaze ice or rime ice are primarily caused by the ice shape affecting the airflow locally and consequently the droplet catch and the resulting ice shape. Ice roughness greatly increases the heat transfer coefficient, stops the movement of drops along the surface, and may also affect the airflow initially and thereby the droplet catch. At high subreezing temperatures the initial flow and shedding of surface drops have a large effect on the ice shape. At the incipient freezing limit, no ice forms. Author

N88-12526*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aero Propulsion Lab.
AIRCRAFT FIRE SAFETY RESEARCH
BENITO P. BOTTERI *In* NASA. Lewis Research Center, Spacecraft Fire Safety p 65-72 1987
Avail: NTIS HC A07/MF A01 CSCL 01C

During the past 15 years, very significant progress has been made toward enhancing aircraft fire safety in both normal and hostile (combat) operational environments. Most of the major aspects of the aircraft fire safety problem are touched upon here. The technology of aircraft fire protection, although not directly applicable in all cases to spacecraft fire scenarios, nevertheless does provide a solid foundation to build upon. This is particularly true of the extensive research and testing pertaining to aircraft interior fire safety and to onboard inert gas generation systems, both of which are still active areas of investigation. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A88-15051
OVERLOOKED POTENTIAL OF SYSTEMS WITH MARKOVIAN COEFFICIENTS
HENK A. P. BLOM (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 1758-1764. refs

The usual system of linear stochastic difference equations with Markovian coefficients is generalized to cover R-exp-n-valued processes which jump simultaneously with and due to jumps of the coefficients. The additional modeling potential is illustrated for a maneuvering aircraft. In addition, candidate algorithms are reviewed for the filtering of partial observations of the generalized system; these include the generalized pseudo Bayes algorithm and the interacting multiple model algorithm. B.J.

A88-15115
APPLICATIONS OF DAMAGE TOLERANCE ANALYSIS TO IN-SERVICE AIRCRAFT STRUCTURES
D. R. SHOWERS, R. L. JANSEN, T. F. CHRISTIAN, JR., and J. A. WAGNER (USAF, Warner Robbins Air Logistics Center, Robbins AFB, GA) IN: Analyzing failures: The problems and the solutions . Metals Park, OH, ASM International, 1986, p. 159-166. refs

An improved method of aircraft structural analysis is presented which is based upon finite element analysis and fracture mechanics techniques. Analytical aspects of durability and damage tolerance analysis are discussed with respect to U.S. Air Force transport and fighter aircraft. A flight-by-flight crack growth methodology is developed, and the advantages of the present method over previous force management techniques are discussed. Application of the method to operational aircraft structural analyses demonstrate the ability of the method to provide rapid input to aircraft structural considerations such as fatigue safety limits and maintenance inspection intervals. R.R.

A88-15360* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH DYNAMIC GPS RECEIVER USING MAXIMUM LIKELIHOOD ESTIMATION AND FREQUENCY TRACKING
W. J. HURD, J. I. STATMAN, and V. A. VILNROTTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-23, July 1987, p. 425-437. refs
(Contract AF TASK RE-182)

A new high dynamic global positioning system (GPS) receiver is presented and its performance characterized by analysis, simulation, and demonstration. The demonstration receiver is a breadboard model capable of tracking a single simulated satellite signal in pseudorange and range rate. Pseudorange and range rate estimates are made once every 20 ms, using a maximum likelihood estimator, and are tracked by means of a third-order fading memory filter in a feedback configuration. The receiver tracks pseudorange with rms errors of under 1 m when subjected to simulated 50 g, 40 g/s circular trajectories. The tracking threshold is approximately 28 dB-Hz, which provides 12 dB margin relative to the minimum specified signal strength, assuming 3.5 dB system noise figure and 0 dBi antenna gain. Author

A88-16123#
AVSAT - AN AERONAUTICAL SATELLITE COMMUNICATIONS SYSTEM
WALTER J. GRIBBIN (Aeronautical Radio, Inc., Annapolis, MD) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p.
(IAF PAPER 87-477)

The projected 'AvSat' system is an industry-owned and -managed global aeronautical satellite system consisting of a ground segment, avionics, and cabin systems, as well as a space segment. AvSat uses a fully integrated digital transmission system for voice and data, based on multichannel, fully interactive TDMA that furnishes total interconnectivity between various aircraft and four earth stations. When fully developed, AvSat will incorporate shared and dedicated satellites in GEO to provide redundant, near-global coverage. O.C.

A88-16126#
PLANNING OF ADVANCED MARITIME AND AERONAUTICAL MOBILE SATELLITE SYSTEM WITH MULTIBEAM FREQUENCY RE-USE
NIZAR SULTAN (Canadian Astronautics, Ltd., Ottawa, Canada) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 7 p. refs
(IAF PAPER 87-480)

The paper is concerned with the optimization of the principal parameters of an advanced mobile satellite system serving a variety of users that are not uniformly distributed, with a limited L-band frequency spectrum requiring frequency reuse among spot beams. The approach used here consists of analyzing the optimum multibeam antenna for maximum frequency reuse capabilities, devising a channelization and routing scheme, modeling the transponder by software and optimizing the payload mass and power for existing buses and launchers. It is shown that an optimized 3.4-meter reflector antenna can handle over fifty thousand vessels and aeroplanes with a 5-MHz L-band frequency reuse configuration using an adaptive subband channelization and reconfigurability system developed here. V.L.

A88-16708
THE INFLUENCE OF HELICOPTER FLIGHT PARAMETERS ON THE RESULTS OF MEASUREMENTS OF HORIZONTAL RADIATION PATTERNS OF VHF/UHF BROADCASTING ANTENNAE
DANIEL J. BEM, JAROSLAW JANISZEWSKI, and RYSZARD ZIELINSKI (Wroclaw, Politechnika, Poland) IN: Electromagnetic compatibility 1986; Proceedings of the Eighth International Wroclaw Symposium, Wroclaw, Poland, June 24-26, 1986. Part 2 . Wroclaw, Poland, Wroclaw Technical University Press, 1986, p. 401-411.

The selection of optimum flight parameters as well as navigation influence on the measurement results are discussed. The corrections which permit a decrease in measurement errors related to inaccurate helicopter navigation are determined. An unconventional method of data processing was elaborated to increase the accuracy of determining the antenna pattern. The efficiency of the methods presented is illustrated with an example. Author

N88-12477*# Theory and Applications Unlimited Corp., Los Gatos, Calif.
GPS VERTICAL AXIS PERFORMANCE ENHANCEMENT FOR HELICOPTER PRECISION LANDING APPROACH
ROBERT P. DENARO and JACQUES BESER Sep. 1986
128 p
(Contract NAS2-11791)
(NASA-CR-177443; NAS 1.26:177443) Avail: NTIS HC A07/MF A01 CSCL 17G

Several areas were investigated for improving vertical accuracy for a rotorcraft using the differential Global Positioning System (GPS) during a landing approach. Continuous deltaranging was studied and the potential improvement achieved by estimating acceleration was studied by comparing the performance on a constant acceleration turn and a rough landing profile of several

filters: a position-velocity (PV) filter, a position-velocity-constant acceleration (PVAC) filter, and a position-velocity-turning acceleration (PVAT) filter. In overall statistics, the PVAC filter was found to be most efficient with the more complex PVAT performing equally well. Vertical performance was not significantly different among the filters. Satellite selection algorithms based on vertical errors only (vertical dilution of precision or VDOP) and even-weighted cross-track and vertical errors (XVDOP) were tested. The inclusion of an altimeter was studied by modifying the PVAC filter to include a baro bias estimate. Improved vertical accuracy during degraded DOP conditions resulted. Flight test results for raw differential results excluding filter effects indicated that the differential performance significantly improved overall navigation accuracy. A landing glidepath steering algorithm was devised which exploits the flexibility of GPS in determining precise relative position. A method for propagating the steering command over the GPS update interval was implemented. J.P.B.

N88-12478*# Analytical Mechanics Associates, Inc., Mountain View, Calif.
NAVSIM 2: A COMPUTER PROGRAM FOR SIMULATING AIDED-INERTIAL NAVIGATION FOR AIRCRAFT
WILLIAM S. BJORKMAN Mar. 1987 94 p
(Contract NAS2-10850)
(NASA-CR-177438; NAS 1.26:177438) Avail: NTIS HC A05/MF A01 CSCL 17G

NAVSIM II, a computer program for analytical simulation of aided-inertial navigation for aircraft, is described. The description is supported by a discussion of the program's application to the design and analysis of aided-inertial navigation systems as well as instructions for utilizing the program and for modifying it to accommodate new models, constraints, algorithms and scenarios. NAVSIM II simulates an airborne inertial navigation system built around a strapped-down inertial measurement unit and aided in its function by GPS, Doppler radar, altimeter, airspeed, and position-fix measurements. The measurements are incorporated into the navigation estimate via a UD-form Kalman filter. The simulation was designed and implemented using structured programming techniques and with particular attention to user-friendly operation. Author

N88-12479*# Ohio State Univ., Columbus. ElectroScience Lab.
SIMULATION OF AN ENHANCED TCAS 2 SYSTEM IN OPERATION Semiannual Report
R. G. ROJAS, P. LAW, and W. D. BURNSIDE Oct. 1987 79 p
(Contract NSG-1498)
(NASA-CR-181545; NAS 1.26:181545; ESL-716199-9) Avail: NTIS HC A05/MF A01 CSCL 17G

Described is a computer simulation of a Boeing 737 aircraft equipped with an enhanced Traffic and Collision Avoidance System (TCAS II). In particular, an algorithm is developed which permits the computer simulation of the tracking of a target airplane by a Boeing 373 which has a TCAS II array mounted on top of its fuselage. This algorithm has four main components: namely, the target path, the noise source, the alpha-beta filter, and threat detection. The implementation of each of these four components is described. Furthermore, the areas where the present algorithm needs to be improved are also mentioned. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A88-13381
THE CREST SYSTEM DESIGN
DOUGLAS E. SWANSON and GERALD F. HERNDON (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 27-31.

An adaptive performance ejection seat is developed and demonstrated. Key elements of this system include selectable thrust/attitude control rockets, adaptive restraint, windblast protection, digital flight control, controllable catapult, advanced sensors, and advanced composite structure. This paper presents the system design philosophy, the baseline design concept, and the rationale for subsystem selection. Author

A88-13383
THE CREST SEAT STRUCTURE DEVELOPMENT
GERALD F. HERNDON and DOUGLAS E. SWANSON (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 39-43.

The advanced composite seat structure of the CREST escape system is discussed. The system incorporates an advanced composite shell structure that consolidates all of the pertinent subsystems into an ejection seat designed to support, position, and restrain a crew member in an aircraft cockpit during normal flight operations and provide support, restraint, and windblast protection during an emergency escape ejection episode. The baseline design concept, structural analysis techiques and results, and special manufacturing considerations for the structure are examined. C.D.

A88-13384
THE CREST WINDBLAST PROTECTION SYSTEM DESIGN
SAMUEL T. MAYNARD and DOUGLAS E. SWANSON (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 44-47. refs

The design characteristics and rationale used for selecting a CREST windblast protection system configuration are discussed. The head/upper extremity protection subassembly and the lower extremity protection subassembly are described. Transonic and subsonic wind tunnel tests which demonstrate the effectiveness of this system under high and low speed conditions are reviewed. C.D.

A88-13391
INTRODUCING THE MK15 EJECTION SEAT
BRIAN A. MILLER (Martin-Baker Aircraft Co., Ltd., Higher Denham, England) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 106-111.

The case for ejection seats in turboprop trainer aircraft is reviewed, and the Mk15 ejection seat system is described. The main problem areas addressed in developing this system are discussed, including those related to eye position and sitting position, maintaining ejection path clearance and assuming minimal airframe changes resulting from the installation of the system, affording maximum pilot field of view and canopy bow clearance, and minimizing weight. The mode of operation of the system and the resulting stable trajectory are described. C.D.

A88-13394
CREST FLIGHT CONTROLLER
F. D. N. GOULD, J. W. MACHIA, and I. S. MEHDI (Boeing Military Airplane Co., Seattle, WA) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 122-127.

The requirements and design details of the CREST Flight Controller hardware are described. The main controller, hand-off circuitry, backup sequencer, power supply, and flight data recorder are addressed. The software which performs the required built-in-test, normal flight, and crew escape functions is also described. C.D.

A88-13395
NACES - THE PROGRAM AND THE SEAT
BRIAN A. MILLER (Martin-Baker Aircraft Co., Ltd., Higher Denham, England) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 134-139.

The development of the Navy Aircrew Common Ejection Seat (NACES) is discussed. The aspects of the project addressed here include cost, system performance, assurance of maintainability and reliability, minimizing of integrated logistic support/lifecycle costs, and ease of manufacture. The phases of the program are summarized, and a status report is given. C.D.

A88-13399
CHALLENGES OF DEVELOPING CONTROLLABLE PROPULSION FOR THE CREW ESCAPE TECHNOLOGIES (CREST) SEAT
W. L. GRASER, J. E. GLOD, and P. E. LUCAS (Morton Thiokol, Inc., Elkton, MD) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 168-173.

The CREST rocket motor assembly, which consists of two major subassemblies, the main thrust subassembly (MTS) and the attitude control subassembly (ACS), is discussed. The thrust vector nozzles, bit motors, manifold, and hydraulic power unit of the MTS are described. The gas generator design, hot gas valve, and hot gas tubing of the ACS are addressed. C.D.

A88-13539
NACES P3I AND BEYOND
BRIAN A. MILLER (Martin-Baker Aircraft Co., Ltd., Higher Denham, England) SAFE Journal, vol. 17, Fall 1987, p. 22-26.

The U.S. Navy aircrew common ejection seat (NACES) P3I program was created to enable the progressive updating of the baseline seat to ensure that it meets the state-of-the-art standards. Designated the Mk14, the ejection seat incorporates a modular design concept, with each subsystem largely self-contained and capable of improvement or replacement without affecting other subsystems. The P3I program implementation concept is discussed as well as Update I, automatic liferaft inflation, databus interlink, passive arm restraint, diversification, and repackaging. K.K.

A88-13540
ADVANCED TECHNOLOGY COCKPIT PROGRAM
JACOB EYTH, JR. (U.S. Navy, Naval Air Development Center, Warminster, PA) SAFE Journal, vol. 17, Fall 1987, p. 27-32.

The Advanced Technology Cockpit (ATC) Program, conducted by the Naval Air Development Center, was initiated in FY84 with the goal of redesigning the crewstation with primary emphasis on the pilot. The expected payoffs from using the ATC include improved high g onset and sustained g capability using articulating seat positioning, addition of laser protection through canopy filtering techniques, and improved man-machine interfaces through the use of voice interaction and decision aids. A transition from the 6.2 program to the 6.3 program is planned in FY88 for the development of a full-scale dynamic demonstrator. K.K.

A88-13973
INCLINED PLANES
IAN GOOLD Flight International (ISSN 0015-3710), vol. 132, Sept. 26, 1987, p. 34-38.

A study has been conducted under the aegis of NASA-Ames by several VTOL aircraft manufacturers, in order to ascertain the range of tilt-rotor aircraft sizes and configurations that might be economically accomodated by projected passenger market trends. Attention was given to issues associated with aircraft and powerplant certification as well as the overall impact of such civilian aircraft production capacities on the defence industrial base. The tilt-rotor passenger aircraft sizes considered are capable of accomodating 8, 19, 31, 39, and 75 seats. The 31- and 39-seat aircraft are variants of the V-22 Osprey; of these, the smaller is unpressurized, while the larger employs a fully pressurized fuselage. O.C.

A88-14252*# PRC Kentron, Inc., Hampton, Va.
INTEGRATING NONLINEAR AERODYNAMIC AND STRUCTURAL ANALYSIS FOR A COMPLETE FIGHTER CONFIGURATION
KENNETH E. TATUM (PRC Kentron, Inc., Hampton, VA) and GARY L. GILES (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 10 p. refs
(AIAA PAPER 87-2863)

The coupling of a nonlinear aerodynamics program with a structural analysis program to include the effects of static aeroelasticity in early preliminary design studies is described. A nonlinear, full potential aerodynamics method with capability to model geometric details of a complete aircraft in supersonic flow is used. The deflections of the lifting surfaces are calculated using an equivalent plate structural representation which can readily accommodate the changes in stiffness and geometric properties required during the preliminary design process. An iterative solution procedure is used to obtain consistent aerodynamic loads and structural deflections at the specified flight conditions. The volume of data transmitted between programs is minimized. The procedure is applied to a complete aircraft and the numerical results illustrate the aeroelastic effects on pressure distribution as well as total forces and moments. During this design study, the thickness distribution of the wing cover skins was initially sized based on rigid loads and subsequently resized under aeroelastic loads. Comparisons are made between these nonlinear aeroelastic results and results obtained from linear aerodynamic methods applied to a rigid shape during conceptual design studies. Author

A88-14253#
EXPLOITING THE CLOSE-COUPLED CANARD
J. D. MARTIN (Embry-Riddle Aeronautical University, Daytona Beach, FL) and N. R. FOSTER (Development Engineering Resources, Inc., Port Orange, FL) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 7 p. refs
(AIAA PAPER 87-2864)

Canard, tandem wing, and three surface aircraft configurations are popular subjects of analytical and windtunnel studies. This paper describes an approach for exploiting the aerodynamic advantages of a close-coupled wing and canard while minimizing the disadvantages. A mission statement was formulated; a preliminary close-coupled canard configuration was established; windtunnel testing was conducted to verify previous study results and new design characteristics; and finally, the close-coupled canard concept was committed to structural design and fabrication. Proof-of-concept flight-test is scheduled for Spring 1988 while research investigations using this subsonic technology demonstration vehicle will extend into 1990. In addition to demonstrating performance and flight handling qualities, unique airframe modularity permits exploration of alternate configurations. Author

A88-14254#
A METHOD TO OPTIMIZE NACELLE SHAPE IN A SUPERSONIC CRUISE AIRCRAFT
REINER SUIKAT and SAEED FAROKHI (Kansas, University, Lawrence) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 8 p. refs
(AIAA PAPER 87-2865)

A computer program is developed to optimize the shape of a nacelle installed in a supersonic aircraft for minimum drag. The program is also capable of optimizing the wing camber of the same aircraft. As a unique feature, the present code accounts for the aerodynamic forces on the entire airplane, in contrast to previous wing camber optimization codes which included only the wing forces. The program is based on a panel method analysis code by Woodward and the accuracy of the program is checked with the available wind tunnel data on isolated components as well as full configurations. The computed results are in general agreement with the available data. The results of several optimization test runs are presented and show agreement with trends predicted by other researchers based on theoretical and experimental studies. At higher angles of attack, when supersonic vortex lift becomes significant, the analysis code underpredicts the aircraft lift coefficient. Author

A88-14258*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
THE VALUE OF EARLY FLIGHT EVALUATION OF PROPULSION CONCEPTS USING THE NASA F-15 RESEARCH AIRPLANE
FRANK W. BURCHAM, JR. and RONALD J. RAY (NASA, Flight Research Center, Edwards, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 13 p. refs
(AIAA PAPER 87-2877)

The value of early flight evaluation of propulsion and propulsion control concepts was demonstrated on the NASA F-15 airplane in programs such as highly integrated digital electronic control (HIDEC), the F100 engine model derivative (EMD), and digital electronic engine control (DEEC). (In each case, the value of flight demonstration was conclusively demonstrated.) This paper describes these programs, and discusses the results that were not expected, based on ground test or analytical prediction. The role of flight demonstration in facilitating transfer of technology from the laboratory to operational airplanes is discussed. Author

A88-14262#
THRUST SAVINGS LIMITATIONS WITH BLOWN HIGH LIFT WINGS
J. L. LOTH and M. S. FUNK (West Virginia University, Morgantown) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 9 p. Research supported by Lockheed-Georgia Co. refs
(AIAA PAPER 87-2884)

In the present method for ascertaining the relationship between airframe aerodynamics and thrust requirements in powered high lift systems, attention is given to the minimum installed vector thrust that is required for equilibrium level flight. The available excess thrust for forward acceleration is integrated to provide both the transition time and total impulse required for horizontal acceleration from minimum liftoff speed to a reference velocity at which dynamic pressure equals wing loading. The easily interpreted results then appear as the thrust/weight ratio and a dimensionless flight speed. While various high lift systems have widely differing lift augmentation ratios, their transition flight performance is noted to be similar. O.C.

A88-14263#
A COMPARISON OF FLUTTER ANALYSES FOR A 45 DEG SWEPT MODEL
EDMUND PENDLETON, MARK FRENCH, and THOMAS NOLL (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 14 p. refs
(AIAA PAPER 87-2886)

This paper presents a comparison of results from subsonic and supersonic flutter analyses for a thin, swept wing wind tunnel model. Three computer codes, NASTRAN, FASTOP, and the new ASTROS computer code, were used to perform the analyses. The subsonic doublet lattice method and the supersonic Mach box method and Potential Gradient Method were utilized in these codes. The aim of this paper is to assist in identifying both the strengths and weaknesses in the flutter capability currently existing in government versions of these codes, and to point out possible improvements which may enhance the flutter capability in the still maturing ASTROS code. Author

A88-14266#
THE B. AE. HAWK - A FIRST DECADE OF DEVELOPMENT
J. E. CHACKSFIELD (British Aerospace, PLC, Military Aircraft Div., Kingston-upon-Thames, England) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 7 p.
(AIAA PAPER 87-2911)

A development history and current status evaluation is presented for the Hawk family of jet-powered military trainers and light attack aircraft. The single-seat Hawk Mk. 200 variant of the Hawk Mk. 100 two-seat trainer incorporates radar equipment and guns in place of the forward cockpit; aerodynamic and Adour Mk 871 powerplant improvements over previous variants yield excellent hot/high condition mission effectiveness, together with enhancements of attack speed and agility. An 80-percent structural commonality is maintained between the Mk. 200 and the earlier Mk. 60 and Mk. 100 variants. O.C.

A88-14269#
AERODYNAMIC INTEGRATION OF AFT-MOUNTED UHB PROPULSION SYSTEMS
D. F. VERNON and J. P. HUGHES (Douglas Aircraft Co., Long Beach, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 12 p. refs
(AIAA PAPER 87-2920)

This paper discusses the aerodynamics issues accompanying aft-pylon-mount Ultra High Bypass (UHB) propulsion installations. An overview is presented of the design, testing, and analysis methods utilized to address these isues. Results from both low-speed and high-speed wind tunnel tests are used to validate several computational fluid dynamics (CFD) methods which address the issues critical to UHB/aircraft integration. Verification of the nacelle-pylon rigging and buffet performance is accomplished through the examination of lift, drag, pitching moment, and surface static pressure data. Qualitative aspects of aircraft and power induced flowfield interactions are provided using oil flow visualization techniques during wind tunnel testing as well as color graphics display of both experimental and calculated data. Details of pylon, fuselage, and wing wake effects on fan onset flow distortion are obtained through the use of a rotating nacelle based total pressure rake. The effect of power on aircraft performance predictions is addressed by definition of a viable thrust-drag accounting procedure which utilizes test results in conjunction with a theoretical blade performance method. Author

A88-14270#
INSTALLATION OF INNOVATIVE TURBOFAN ENGINES ON CURRENT TRANSPORT AIRPLANES
MICHAEL G. DUNICAN (Boeing Commercial Airplane Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 6 p.
(AIAA PAPER 87-2921)

Modern turbofan engines with bypass ratios near 5:1 are reaching a fuel efficiency plateau. Further major improvements in these engines are unlikely because of practical limits to component efficiencies. One way to further reduce engine fuel consumption is to increase bypass ratio, which produces higher propulsive efficiency, but also increases power plant drag and weight. A study of the installation of higher bypass ratio engines on the 747 and 767 has been completed. The trades in engine fuel consumption, weight and drag have been evaluated and the installation constraints have been identified. Author

A88-14274#
MD-11 DESIGN - EVOLUTION, NOT REVOLUTION
GEORGE G. FIELD (Douglas Aircraft Co., Long Beach, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 7 p.
(AIAA PAPER 87-2928)

A tradeoff/benefit evaluation is conducted for a 1990-marketable derivative of a current airliner design. The MD-11 is derived from the DC-10 Series 30 aircraft by way of changes which significantly improve aerodynamic performance; in addition, more advanced engines, cockpit systems and cabin interior configuration concepts are incorporated. The retention of the basic DC-10 structure and components, which have known operational, reliability, and manufacturing cost characteristics, thereby forms the basis for an economically successful evolutionary design. Both passenger and freighter versions are envisaged. O.C.

A88-14276#
FUSELAGE SELF-PROPULSION BY STATIC-PRESSURE THRUST - WIND-TUNNEL VERIFICATION
FABIO R. GOLDSCHMIED AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 21 p. refs
(AIAA PAPER 87-2935)

The novel concept of body self-propulsion by static-pressure thrust has been introduced and verified in the wind-tunnel by direct integration of radial pressure distributions for self-propelled axisymmetric bodies with slot suction BLC and stern jet discharge. This concept also means that power can be supplied only to BLC, since the jet discharge is achieved at jet total-head equal to free-stream's; the skin-friction drag is offset entirely by the pressure thrust. It is the most efficient form of body self-propulsion. It also has been shown that 50 percent power reduction has been achieved as compared to the test body/wake-propeller NASA configuration, with only 15 percent of its mass flow. A total aircraft power reduction of 40 percent to 60 percent is feasible as compared to current General Aviation aircraft at 200 MPH cruise speed.
Author

A88-14284*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
PRELIMINARY FLIGHT ASSESSMENT OF THE X-29A ADVANCED TECHNOLOGY DEMONSTRATOR
JOHN W. HICKS and NEIL W. MATHENY (NASA, Flight Research Center, Edwards, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 13 p. refs
(AIAA PAPER 87-2949)

Several new technologies integrated on the X-29A advanced technology demonstrator are being evaluated for the next generation of fighter aircraft. Some of the most noteworthy ones are the forward-swept wing, digital fly-by-wire flight control system, close-coupled wing-canard configuration, aeroelastically tailored composite wing skins, three-surface pitch control configuration, and a highly unstable airframe. The expansion of the aircraft 1-g and maneuver flight envelopes was recently completed over a two-year period in 84 flights. Overall flight results confirmed the viability of the aircraft design, and good agreement with preflight predictions was obtained. The individual technologies' operational workability and performance were confirmed. This paper deals with the flight test results and the preliminary evaluation of the X-29A design and technologies. A summary of the primary technical findings in structural static loads, structural dynamic characteristics, flight control system characteristics, aerodynamic stability and control, and aerodynamic performance is presented. Author

A88-14285#
THE PAYOFF OF A DEDICATED FLIGHT TEST AIRCRAFT FOR THE MD-80 FAMILY
HAROLD K. CHENEY and CHARLES F. HOLZER (Douglas Aircraft Co., Long Beach, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 6 p.
(AIAA PAPER 87-2950)

For the MD-80 family of commercial aircraft, Fuselage 909 was dedicated to flight test aircraft improvements. Following the use of 909 for the FAA certification demonstrations of the MD-81 version, the aircraft was assigned to the overall MD-80 program, and used to test a number of improvement items developed before certification by the FAA. This saved the time and expense of instrumenting and using production aircraft for these tasks. Nearly all of the MD-83 development and certification flight testing was accomplished using 909. In supporting the MD-80 family of derivative aircraft, 909 has flown 1,660 flights and 2,440 flight hours. Currently, it is embarking on its latest adventure of confirming the concept of the ultra-high-bypass-ratio propulsion system. This paper summarizes the accomplishments of Fuselage 909 and the payoffs obtained from use of this dedicated test aircraft in development of a family of derivative aircraft. Author

A88-14287*# Houston Univ., Tex.
COMPROMISE - AN EFFECTIVE APPROACH FOR CONCEPTUAL AIRCRAFT DESIGN
FARROKH MISTREE (Houston, University, TX), STERGIOS MARINOPOULOS, DAVID JACKSON, and JON SHUPE AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 12 p. refs
(Contract NAS1-18117)
(AIAA PAPER 87-2965)

The Decision Support Problem (DSP) technique for aircraft design is presently demonstrated through the development of a compromise DSP template for the conceptual design of subsonic transport aircraft. System variables are wing span and area, fuselage diameter and length, takeoff weight, and installed thrust. Such system constraints as range and wing loading are represented algebraically using standard subsonic aircraft theory, and economic efficiency is modeled in terms of rates-of-return. The DSP template thus obtained has been tested and validated using the known mission requirements and design constants of the B 727-200 airliner. O.C.

A88-14305
THE DESIGN, DEVELOPMENT AND CONSTRUCTION OF THE UM10 ULTRALIGHT NON-RIGID AIRSHIP
THOMAS S. BERGER (Ulita Manufacturing Co., Sheboygan, WI) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 1 . London, Royal Aeronautical Society, 1986, p. 5.1 to 5.11.

Configurational design features and performance projections are presented for the small, lightweight UM10 nonrigid airship, with attention to propulsion system configuration and control car structure and empenage support details. The UM10 is envisioned as a platform for LTA vehicle flight crew training, commercial advertising, and aerial photography. It is noted to incorporate as its most advanced feature a pair of vectoring thrusters, mounted on outriggers attached to the control car. O.C.

A88-14307
A FLYING SAUCER??? YOU ARE CRAZY!!!
MARIO SANCHEZ ROLDAN (Spacial, Mexico) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 1 . London, Royal Aeronautical Society, 1986, p. 9.1 to 9.5.

An account is given of the results of ten years of research efforts and four years of prototype construction activities for geodetic-frame lenticular rigid airships. The first prototype built was destroyed by storm damage to its hangar. The present prototype employs six gas cells within the rigid envelope, and incorporates two 90-hp engines on either side of the craft behind the gondola. The entire engine/propeller unit can be swiveled 110 deg down and 30 deg up, in order to furnish greater controllability at low speeds. An on-board microprocessor is used for control system automation. O.C.

A88-14316
TOROIDAL BALLOON CONCEPT
F. TODD (Todd Transport Design, Canada) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 19.1 to 19.10.

The toroidal balloon concept (TBC) applies to a semirigid airship using a toroidal flexible envelope with a rigid structure carrying a propeller/fan propulsion system at its center together with cabin, control systems, and landing gears. In order to be able to haul a 20-ton payload, a TBC would have a 200-ft overall diameter, together with a 40-ft duct/fan propulsion system that was driven by turboshaft powerplant(s) generating a total of 8000 SHP. Attention is given to comparisons between TBC and helicopter performance in several typical missions. O.C.

A88-14317
THE CASE FOR A SOLAR POWERED AIRSHIP
GABRIEL A. KHOURY (Imperial College of Science and Technology, London, England) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 20.1 to 20.61. refs

A comprehensive design feasibility study is conducted for a 80-m long, solar-cell powered airship incorporating state-of-the-art structures, materials, control, and propulsion resources with equally advanced photovoltaic, electrical powertrain, and energy storage systems. Attention is given to the mounting of solar cell arrays on the airship hull surfaces, seasonal and geographical latitude effects, performance projections under various insolation conditions, and the flywheel, storage battery and fuel cell alternatives for energy storage. Detailed calculations of energy economies are presented. O.C.

A88-14370
X-31A
WOLFGANG B. HERBST (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) SAE, Aerospace Vehicle Conference, Washington, DC, June 8-10, 1987. 8 p.
(SAE PAPER 871346)

A West German/USA experimental aircraft program has been instituted to develop the technology base of 'supermaneuverability' characteristics; the extension of fighter aircraft maneuver envelope that this represents calls for a pushing back of the stall barrier to as much as 70-deg angle-of-attack. The unprecedentedly small turn radii thus generated will be the basis of three-dimensional maneuvers of great tactical significance in future air combat with 'all-aspect' weapons. The key to supermaneuverability is thrust vectoring in pitch and yaw; this also enhances the decoupling of fuselage gun aiming and flight path control. O.C.

A88-14373* Massachusetts Inst. of Tech., Cambridge.
FLIGHT RESEARCH WITH THE MIT DAEDALUS PROTOTYPE
STEVEN R. BUSSOLARI, HAROLD H. YOUNGREN (MIT, Cambridge, MA), and JOHN S. LANGFORD (Institute for Defense Analyses, Alexandria, VA) SAE, Aerospace Vehicle Conference, Washington, DC, June 8-10, 1987. 9 p. NASA-USAF-supported research. refs
(SAE PAPER 871350)

The MIT Light Eagle human-powered aircraft underwent long-duration testing over Rogers Dry Lake in California during January, 1987. Designed as a prototype for the MIT Daedalus Project, the Light Eagle's forty-eight flights provided pilot training, established new distance records for human-powered flight, and provided quantitative data through a series of instrumented flight experiments. The experiments focused on: (1) evaluating physiological loads on the pilot, (2) determining airframe power requirements, and (3) developing an electronic flight control system. This paper discusses the flight test program, its results and their implications for the follow-on Daedalus aircraft, and the potential uses of the Light Eagle as a low Reynolds number testbed.
Author

A88-15226
IN-FLIGHT THRUST DETERMINATION AND UNCERTAINTY
Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-674), 1986, 412 p. For individual items see A88-15227 to A88-15228.
(SAE SP-674)

The conference presents papers on in-flight thrust determination, the uncertainty of in-flight thrust determination, and the measurement evaluation process used in propulsion ground test facilities. Other topics include the development of in-flight thrust measurement procedures for an afterburning turbofan engine, and measurement uncertainty methodology. Consideration is also given to the uncertainty methodology for in-flight thrust determination. K.K.

A88-15227* Pratt and Whitney Aircraft, East Hartford, Conn.
IN-FLIGHT THRUST DETERMINATION
ROBERT B. ABERNETHY (Pratt and Whitney, East Hartford, CT), GARY R. ADAMS (USAF, Wright-Patterson AFB, OH), JOHN C. ASCOUGH (Royal Aircraft Establishment, Farnborough, England), JENNIFER L. BAER-RIEDHART (NASA, Flight Research Center, Edwards, CA), GEORGE H. BALKCOM (General Dynamics Corp., Saint Louis, MO), THOMAS BIESIADNY (NASA, Lewis Research Center, Cleveland, OH) et al. (SAE Aerospace Information Report, SAE AIR 1703, Nov. 1985) IN: In-flight thrust determination and uncertainty . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, 234 p. refs
(SAE AIR 1703)

The major aspects of processes that may be used for the determination of in-flight thrust are reviewed. Basic definitions are presented as well as analytical and ground-test methods for gathering data and calculating the thrust of the propulsion system during the flight development program of the aircraft. Test analysis examples include a single-exhaust turbofan, an intermediate-cowl turbofan, and a mixed-flow afterburning turbofan. K.K.

A88-15228* Pratt and Whitney Aircraft, East Hartford, Conn.
UNCERTAINTY OF IN-FLIGHT THRUST DETERMINATION
ROBERT B. ABERNETHY (Pratt and Whitney, East Hartford, CT), GARY R. ADAMS (USAF, Wright-Patterson AFB, OH), JOHN W. STEURER (McDonnell Douglas Co., Saint Louis, MO), JOHN C. ASCOUGH (Royal Aircraft Establishment, Farnborough, England), JENNIFER L. BAER-RIEDHART (NASA, Flight Research Center, Edwards, CA), GEORGE H. BALKCOM (General Dynamics Corp., Saint Louis, MO), THOMAS BIESIADNY (NASA, Lewis Research Center, Cleveland, OH) et al. (SAE Aerospace Information Report, SAE AIR 1678, Aug. 1985) IN: In-flight thrust determination and uncertainty . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 243-338. refs
(SAE AIR 1678)

Methods for estimating the measurement error or uncertainty of in-flight thrust determination in aircraft employing conventional turbofan/turbojet engines are reviewed. While the term 'in-flight thrust determination' is used synonymously with 'in-flight thrust measurement', in-flight thrust is not directly measured but is determined or calculated using mathematical modeling relationships between in-flight thrust and various direct measurements of physical quantities. The in-flight thrust determination process incorporates both ground testing and flight testing. The present text is divided into the following categories: measurement uncertainty methodoogy and in-flight thrust measurent processes. K.K.

A88-15381
FUTURE AIRLINER COCKPITS
PIERRE CONDOM Interavia (ISSN 0020-5168), vol. 42, Oct. 1987, p. 1089-1092.

The current A320 airliner cockpit typifies state-of-the-art crew interfaces with their aircraft. The instrument panel is a six-CRT display that provides flight and navigation data in addition to monitoring data for engines and systems. Two other CRTs are associated with the flight management system. Control columns and wheels have been replaced by miniature side-sticks that leave an uninterrupted view of the instrument panel. Attention is presently given to NASA-sponsored technological forecasts concerning the nature of cockpit systems that may enter service beyond 1995. Preprogrammed information-selection will be featured by the multifunctional display panels foreseen. HUDs will also be incorporated for superior operation in runway takeoff/landing approach environments. O.C.

A88-15648
AIRCRAFT EQUIPMENT SYSTEMS [SISTEMY OBORUDOVANIIA LETATEL'NYKH APPARATOV]
A. M. MATVEENKO, ED. and VLADIMIR IVANOVICH BEKASOV, ED. Moscow, Izdatel'stvo Mashinostroenie, 1986, 368 p. In Russian. No individual items are abstracted in this volume.

This textbook contains essential data on some of the principal aircraft equipment systems, including air-conditioning systems, individual life support systems, crew and passenger recovery systems, hydraulic and pneumatic power systems, and deicing and fire prevention systems. Topics discussed include requirements for aircraft equipment systems and their evaluation using the takeoff mass criterion; the physiological and hygienic aspects of high-altitude flight; the operation and main components of the principal aircraft systems; and the general design of automatic control power systems. V.L.

A88-15719*# Sterling Federal Systems, Inc., Palo Alto, Calif.
TRANSONIC AEROELASTICITY OF WINGS WITH TIP STORES
GURU P. GURUSWAMY (Sterling Federal Systems, Inc., Palo Alto, CA), PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA), and EUGENE L. TU (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2, p. 672-683) Journal of Aircraft (ISSN 0021-8669), vol. 24, Oct. 1987, p. 688-695. USAF-supported research. Previously cited in issue 18, p. 2604, Accession no. A86-38948. refs

A88-15724*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A HEATER MADE FROM GRAPHITE COMPOSITE MATERIAL FOR POTENTIAL DEICING APPLICATION
CHING-CHEH HUNG (NASA, Lewis Research Center, Cleveland, OH), MICHAEL E. DILLEHAY, and MARK STAHL (Cleveland State University, OH) Journal of Aircraft (ISSN 0021-8669), vol. 24, Oct. 1987, p. 725-730. Previously cited in issue 09, p. 1197, Accession no. A87-24905. refs

A88-15725*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
STRUCTURAL INFLUENCE OF THE CABIN FLOOR ON SOUND TRANSMISSION INTO AIRCRAFT - ANALYTICAL INVESTIGATIONS
C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 24, Oct. 1987, p. 731-736. Previously cited in issue 22, p. 3223, Accession no. A86-45427. refs
(Contract NAG1-390)

A88-15938*# National Aeronautics and Space Administration, Washington, D.C.
TECHNOLOGY CHALLENGES FOR THE NATIONAL AERO-SPACE PLANE
WILLIAM M. PILAND (NASA, National Aero-Space Plane Program Management Office, Washington, DC) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 10 p.
(IAF PAPER 87-205)

The National Aerospace Plane (NASP) will require an exceptionally high degree of integration between propulsion and aerodynamic configuration, in order to achieve the requisite specific impulse and low structural weight. This is to be achieved through the use of forebody shock compression and afterbody exhaust expansion. Attention is presently given to the materials and structural concepts required for the realization of these NASP airframe functions, in view of the exceptionally high aerothermodynamic loads that will be experienced at hypersonic speeds. Active cooling will have to be used in certain critical airframe and propulsion components. CFD characterizations of these processes must be carefully developed and fully validated. O.C.

A88-16337#
CONTAMINATION CONTROL OF AIRCRAFT HYDRAULIC SYSTEMS
DUNBING CHENG (Flight Test Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, June 1987, p. B245-B250. In Chinese, with abstract in English. refs

This paper describes the forms, routes, and hazards of operating-fluid contamination in aircraft hydraulic systems. Focusing on field maintenance, the paper provides methods and measures for improving hydraulic fluid cleanliness. The paper also proposes an allowable control level of contamination of the hydraulic fluid. Author

A88-16471* Veneklasen (Paul A.) and Associates, Santa Monica, Calif.
LIGHT AIRCRAFT SOUND TRANSMISSION STUDIES - NOISE REDUCTION MODEL
MAHABIR S. ATWAL (Paul S. Veneklasen and Associates, Santa Monica, CA), KAREN E. HEITMAN (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA), and MALCOLM J. CROCKER (Auburn University, AL) Acoustical Society of America, Journal (ISSN 0001-4966), vol. 82, Oct. 1987, p. 1342-1348. refs

Experimental tests conducted on the fuselage of a single-engine Piper Cherokee light aircraft suggest that the cabin interior noise can be reduced by increasing the transmission loss of the dominant sound transmission paths and/or by increasing the cabin interior sound absorption. The validity of using a simple room equation

model to predict the cabin interior sound-pressure level for different fuselage and exterior sound field conditions is also presented. The room equation model is based on the sound power flow balance for the cabin space and utilizes the measured transmitted sound intensity data. The room equation model predictions were considered good enough to be used for preliminary acoustical design studies. Author

A88-16475*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE DESIGN OF A *JOINED WING* FLIGHT DEMONSTRATOR AIRCRAFT
S. C. SMITH, S. E. CLIFF (NASA, Ames Research Center, Moffett Field, CA), and I. M. KROO (Stanford University, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 16 p. refs
(AIAA PAPER 87-2930)

A joined-wing flight demonstrator aircraft has been developed at the NASA Ames Research Center in collaboration with ACA Industries. The aircraft is designed to utilize the fuselage, engines, and undercarriage of the existing NASA AD-1 flight demonstrator aircraft. The design objectives, methods, constraints, and the resulting aircraft design, called the JW-1, are presented. A wind-tunnel model of the JW-1 was tested in the NASA Ames 12-foot wind tunnel. The test results indicate that the JW-1 has satisfactory flying qualities for a flight demonstrator aircraft. Good agreement of test results with design predictions confirmed the validity of the design methods used for application to joined-wing configurations. Author

A88-16556#
MODELS FOR EVALUATING THE PERFORMANCE OF PROPELLER AIRCRAFT ACTIVE NOISE CONTROL SYSTEMS
A. J. BULLMORE, P. A. NELSON, S. J. ELLIOTT (Southampton, University, England), J. F. EVERS, and B. CHIDLEY (British Aerospace, PLC, Manchester, England) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 12 p. refs
(AIAA PAPER 87-2704)

A simple analytical theory is used to model the fuselage structural response of a B.Ae.748 aircraft as that of a finite, isotropic thin cylindrical shell, and the cabin acoustic response as that of a cylindrical room. Theoretical results are compared with measured flight data obtained on the test aircraft. It is shown that, provided the theoretical external acoustic pressure forcing of the shell is representative of the measured propeller pressure field acting on the aircraft fueselage, then the simple model can yield structural and acoustic responses which show good agreement with the measured data. This model is used to predict the effectiveness of an 8 source/24 error sensor active control system when applied to the predicted cabin sound fields at the first (88 Hz) and second (176 Hz) blade passage harmonic frequencies. It is attempted to reduce the average sound levels over a head height plane covering all the seats. Average reductions over the plane of the order of 8 dB for the fundamental frequency and 2 dB for the second harmonic frequency are predicted. These results involve local reductions of up to 35 dB, but the spatial extent of these zones of high level reductions are shown to be smaller for the second harmonic frequency than the fundamental frequency. Author

A88-16558#
DIGITAL CONTROL OF SOUND FIELDS IN THREE-DIMENSIONAL ENCLOSURES
J. V. WARNER and R. J. BERNHARD (Purdue University, West Lafayette, IN) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 9 p. refs
(Contract NSF MSM-85-05834)
(AIAA PAPER 87-2706)

Active noise control has been shown to be a promising solution for reducing noise levels in turboprop aircraft. This paper presents a broad-band active noise control system based upon an off-line frequency domain model obtained from system response measurements. A laboratory test in an 18 passenger airplane fuselage resulted in 10-20 dB reduction of broad-band deterministic noise over a substantial frequency range. However, the sensitivity of the system to environmental changes proved the impracticality of using off-line modeling techniques. Therefore, this paper also presents the results of a simulation study of adaptive active noise control in aircraft. Actual system response measurements of the aircraft were used to simulate the system. The Least Mean Square (LMS) and Recursive Lease Mean Square (RLMS) gradient search techniques were found to be equally capable of modeling the airplane system. Both methods produced at least 10 dB attenuation of broad-band random noise. However, for a dense harmonic sound field, the LMS estimator was superior, attenuating most harmonics by more than 30 dB, where the RLMS estimator reduced most harmonics by only 20 dB. Practical implications of control loop delay on cancellation of non-deterministic sound are also discussed. Author

A88-16575*# Astron Research and Engineering, Santa Monica, Calif.
MEASUREMENTS OF PROPELLER NOISE IN A LIGHT *TURBOPROP AIRPLANE*
J. F. WILBY and E. G. WILBY (Astron Research and Engineering, Santa Monica, CA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 11 p. NASA-supported research. refs
(AIAA PAPER 87-2737)

In-flight acoustic measurements have been made on the exterior and interior of a twin-engined turboprop airplane under controlled conditions to study data repeatability. It is found that the variability of the harmonic sound pressure levels in the cabin is greater than that for the exterior sound pressure levels, typical values for the standard deviation being +2.0 dB and -4.2 dB for the interior, versus +1.4 dB and -2.3 dB for the exterior. When insertion losses are determined for acoustic treatments in the cabin, the standard deviations of the data are typically + or - 6.5 dB. It is concluded that additional factors, such as accurate and repeatable selection of relative phase between propellers, controlled cabin-air-temperatures, installation of baseline acoustic absorption, and measurement of aircraft attitude, should be considered in order to reduce uncertainty in the measured data. Author

A88-16748*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HYPERSONIC STRUCTURES AND MATERIALS - A PROGRESS REPORT
L. ROBERT JACKSON, SIDNEY C. DIXON, DARREL R. TENNEY (NASA, Langley Research Center, Hampton, VA), ALAN L. CARTER (NASA, Ames Research Center, Moffett Field, CA), and JOSEPH R. STEPHENS (NASA, Lewis Research Center, Cleveland, OH) Aerospace America (ISSN 0740-722X), vol. 25, Oct. 1987, p. 24, 25, 28-30.

The weight of a hypersonic, airbreathing SSTO vehicle may be more critical than for any previous aerospacecraft; an evaluation is accordingly made of the development status and applicability of intermetallic compounds, metal-matrix composites, carbon-carbon composites, ceramics, and ceramic-matrix composites applicable to SSTO craft primary structures. Aerothermal, aerothermoelastic, and acoustic loads are high because the airbreathing SSTO vehicle must follow a high dynamic pressure trajectory in order to achieve the requisite propulsive efficiency. Attention is given to the prospects for integral cryogenic tankage and actively hydrogen-cooled airframe and engine structures. O.C.

N88-11648*# Titan Systems, Inc., La Jolla, Calif.
IMPROVEMENTS TO THE ADAPTIVE MANEUVERING LOGIC PROGRAM Final Report
GEORGE H. BURGIN Washington Jun. 1986 189 p
(Contract NAS2-11421)
(NASA-CR-3985; H-1303; NAS 1.26:3985) Avail: NTIS HC A09/MF A01 CSCL 01C

The Adaptive Maneuvering Logic (AML) computer program simulates close-in, one-on-one air-to-air combat between two fighter aircraft. Three important improvements are described. First, the

previously available versions of AML were examined for their suitability as a baseline program. The selected program was then revised to eliminate some programming bugs which were uncovered over the years. A listing of this baseline program is included. Second, the equations governing the motion of the aircraft were completely revised. This resulted in a model with substantially higher fidelity than the original equations of motion provided. It also completely eliminated the over-the-top problem, which occurred in the older versions when the AML-driven aircraft attempted a vertical or near vertical loop. Third, the requirements for a versatile generic, yet realistic, aircraft model were studied and implemented in the program. The report contains detailed tables which make the generic aircraft to be either a modern, high performance aircraft, an older high performance aircraft, or a previous generation jet fighter. Author

N88-11649# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
ROTORCRAFT DESIGN FOR OPERATIONS
Jun. 1987 319 p In ENGLISH and FRENCH Symposium held in Amsterdam, Netherlands, 13-16 Oct. 1986
(AGARD-CP-423; ISBN-92-835-0420-8) Avail: NTIS HC A14/MF A01

The objective was to explore the impact of operational needs on the evolution of rotorcraft design. The status of rotorcraft design is reviewed and priorities and neglected topics are discussed.

N88-11650# Army Aviation Systems Command, St. Louis, Mo.
THE INFLUENCE OF OPERATIONAL REQUIREMENTS ON LHX CONCEPT FORMULATION
ROBERT D. HUBBARD and ROBERT L. TOMAINE *In* AGARD, Rotorcraft Design for Operations 8 p Jun. 1987
Avail: NTIS HC A14/MF A01

The U.S. Army's Light Helicopter Family (LHX) program which is currently in concept formation is discussed. The activities associated with concept formation including governing regulations, how the process is executed, the scope of the effort involved and innovations included for LHX are discussed. The evolution of the requirements is emphasized and the focus is on how the operational requirements drive the engineering requirements and ultimately the design of the aircraft. Operational requirements are driven by the LHX concept, namely, a family of Scout/Attack (LHX/SCAT) and Utility (LHX-U) aircraft with common dynamic components, core mission equipment and common subsystems. The impacts of the unique LHX-SCAT aircraft on the design of and commonality with the LHX-U are discussed. The operational requirements are categorized into those associated with the Army 21 concept of the future battlefield, the threat, safety and reliability, and availability and maintainability. Each category results in several specific design impacts. Author

N88-11651# KLM Helikopters B.V., Amsterdam (Netherlands).
DESIGN REQUIREMENTS FOR FUTURE COMMERCIAL OPERATIONS
F. F. J. SCHAPER *In* AGARD, Rotorcraft Design for Operations 14 p Jun. 1987
Avail: NTIS HC A14/MF A01

Design requirements for helicopters stemming from civil operations are discussed. The offshore oil and gas industry is and will continue to be the main application of civil helicopters. Development of other commercial markets will require major improvements in almost all areas. Some of these areas are highlighted, including: safety, reliability, cockpit ergonomics, and vibration. The current rate of progress is considered to be much too slow and concern is expressed about military and civil requirements drifting too far apart. Designers of new military helicopters should be aware of these civil requirements and take them into account as much as possible. Author

N88-11652# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.
MISSION-ORIENTED FLYING QUALITIES CRITERIA FOR HELICOPTER DESIGN VIA IN-FLIGHT SIMULATION
B. GMELIN, H.-J. PAUSDER, and P. HAMEL *In* AGARD, Rotorcraft Design for Operations 14 p Jun. 1987
Avail: NTIS HC A14/MF A01

Some recent activities and results in the fields of rotorcraft in-flight simulation are presented. The following general conclusions were drawn: (1) general purpose in-flight simulators will play a decisive role in the rotorcraft design, evaluation, development, and certification process; (2) the capability of in-flight simulators will support industry to meet the demands for future rotorcraft systems and to reduce the costs and risks of development programs; and (3) for the generation of generic flying qualities, test vehicles providing adequate mission performance and variable characteristics are required. Author

N88-11657# Army Aviation Research and Development Command, Moffett Field, Calif.
MODELING XV-15 TILT-ROTOR AIRCRAFT DYNAMICS BY FREQUENCY AND TIME-DOMAIN IDENTIFICATION TECHNIQUES
MARK B. TISCHLER and JUERGEN KALETKA (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, West Germany) *In* AGARD, Rotorcraft Design for Operations 20 p Jun. 1987
Avail: NTIS HC A14/MF A01

Models of the open-loop hover dynamics of the XV-15 Tilt-Rotor Aircraft are extracted from flight data using two approaches: frequency domain and time-domain identification. Both approaches are reviewed and the identification results are presented and compared in detail. The extracted models are compared favorably, with the differences associated mostly with the inherent weighing of each technique. Step responses are used to show that the predictive capability of the models from both techniques is excellent. Based on the results of this study, the relative strengths and weaknesses of the frequency and time-domain techniques are summarized and a proposal for a coordinated parameter identification approach is presented. Author

N88-11658# Royal Aircraft Establishment, Farnborough (England).
OPERATIONAL LOAD MEASUREMENTS ON SERVICE HELICOPTERS
DOROTHY M. HOLFORD *In* AGARD, Rotorcraft Design for Operations 12 p Jun. 1987
Avail: NTIS HC A14/MF A01

The philosophy of operational load measurement programs as applied to rotary wing aircraft is reviewed. A major aim is to substantiate component fatigue lives in the light of operational usage. The aircraft installation to meet the needs of the programs is described. The analysis techniques, which are designed to provide the operator and engineer with a view of the origins of fatigue damage, are described. Problem areas in comprehensive fatigue monitoring systems are discussed. Author

N88-11663# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
IMPACTS OF ROTOR HUB DESIGN CRITERIA ON THE OPERATIONAL CAPABILITIES OF ROTORCRAFT SYSTEMS
R. SCHINDLER and E. PFISTERER *In* AGARD, Rotorcraft Design for Operations 23 p Jun. 1987
Avail: NTIS HC A14/MF A01

Starting with the description of the different design principles of articulated, see-saw, hingeless and bearingless rotor concepts, a variety of realized constructions is presented and discussed. The flight mechanic aspects such as maneuverability and handling qualities are explained with respect to their operational capabilities. The differences in the flapping hinge offset are discussed. The tend of the flapping hinge offset over three decades of armed and utility helicopters is analysed. Author

N88-11664# Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.
NEW AERODYNAMIC DESIGN OF THE FENESTRON FOR IMPROVED PERFORMANCE
A. VUILLET and F. MORELLI *In* AGARD, Rotorcraft Design for Operations 11 p Jun. 1987
Avail: NTIS HC A14/MF A01

A general definition of the fenestron and its advantages for civil and military helicopters are given. A detailed airflow analysis through the fenestron was recently achieved on the tail rotor bench in hover. The experimental technique and the flow measurements are surveyed. Also presented are the correlations made with blade element theory as well as more advanced analysis derived from a radial equilibrium code in use for compressors. Author

N88-11665# Sikorsky Aircraft, Stratford, Conn. Research and Advanced Design.
ROTORCRAFT DESIGNS FOR THE YEAR 2000
EVAN A. FRADENBURGH *In* AGARD, Rotorcraft Design for Operations 11 p Jun. 1987
Avail: NTIS HC A14/MF A01

Some of the rotorcraft concepts that can offer higher speeds than the pure helicopter, including the compound helicopter, ABC, tilt-rotor, X-wing, and stowed rotor configurations are discussed. All of these are potentially practical aircraft. Economic considerations will dictate that the pure helicopter is here to stay; higher speed rotorcraft are not as cost effective at short distances. Also examined is the approach to helicopter sizing for heavy-lift applications. It is concluded that a super-large helicopter, sized to carry the heaviest payload needed, is unaffordable. A better solution is to develop a moderately large helicopter that will carry most of the required loads, and to use the twin-lift technique to transport the occasional extra-heavy load. Author

N88-11666# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
HELICOPTER (PERFORMANCE) MANAGEMENT
WINFRIED BENNER and ROLF DUESSMAN *In* AGARD, Rotorcraft Design for Operations 9 p Jun. 1987
Avail: NTIS HC A14/MF A01

The next generation of military helicopters will have to fly under night and adverse weather conditions below tree top level. Dornier System started 15 years ago to develop avionic systems with a performance that would allow pilots to fly the new missions. In the Dornier baseline display cockpit concept the first steps of the Helicopter Management System (HMS) will be realized. Here, the main aspects of the system are discussed. The main parts are the mission planning system on the ground and the HMS onboard the helicopter. Author

N88-11669# Costruzioni Aeronautiche Giovanni Agusta S.p.A., Varese (Italy).
A129 ADVANCED SOLUTIONS FOR MEETING TODAY'S COMBAT HELICOPTER REQUIREMENT
GIUSEPPE VIRTUANI *In* AGARD, Rotorcraft Design for Operations 9 p Jun. 1987
Avail: NTIS HC A14/MF A01

It is argued that the A129 light attack helicopter represents the answer to modern and severe operational requirements. The main rotar hub and transmission are described as examples of unconventional and advanced technology design. The engine installation represents the case of a configuration where the operative requirement induced a deep physical integration among the subsystems. The large computer structure, the integrated multiplexing system based on the multiplexing and microprocessor technologies, constitutes a major example of functional integration between the helicopter and mission subsystem. Author

N88-11672# Agusta S.p.A., Milan (Italy).
THE EH-101 INTEGRATED PROJECT: A NAVAL, UTILITY AND COMMERCIAL HELICOPTER SYSTEM
PIETRO ALLI, RUGGERO BALDASSARRINI, GIOVANNI MARZORATI, GIOVANNI PAGLIARO, and LUCIANO ARMITI *In* AGARD, Rotorcraft Design for Operations Jun. 1987
Avail: NTIS HC A14/MF A01

The Royal Navy and Marina Militare Italiana tasked EHI to develop a new shipborne helicopter. The two Navies defined a common set of requirements related to the basic common helicopter plus a dedicated different set for each specific mission. Concurrently EHI performed autonomous research on the potential EH 101 civil and utility market. Through those analysis EHI came to the conclusion that a common basic helicopter could satisy all of the requirements even if the roles were sometimes very different. The rationale and the trade off approach which were successfully devised and implemented to produce an aircraft with the best compromise of performance and cost are given. Author

N88-11673# Vibration Inst., Clarendon Hills, Ill.
THE SHOCK AND VIBRATION DIGEST, VOLUME 19, NO. 11 Monthly Report
JUDITH NAGLE-ESHLEMAN, ed. Nov. 1987 56 p
Avail: NTIS HC A04/MF A01

The airworthiness of a long-life jet transport structure is discussed. The book review of Dynamic Fracture is presented. Also included are abstracts for the following subjects: machines; structures; vehicles; testing systems; mechanical components; structural components; materials; experimental techniques; mathematical models; computational methods; modeling techniques; design; and criteria, standards, and specifications.

N88-11674# Boeing Commercial Airplane Co., Seattle, Wash.
AIRWORTHINESS OF LONG-LIFE JET TRANSPORT STRUCTURES
U. G. GORANSON *In* Vibration Inst., The Shock and Vibration Digest, Volume 19, No. 11 p 3-14 Nov. 1987
Avail: NTIS HC A04/MF A01

The criteria and procedures used to design long-life damage-tolerant aircraft structures are outlined. A damage tolerance rating system allows recognition of opportunities for damage detection in a fleet of aircraft. The system is an efficient measure of operator inspection activities and allows coordinated manufacturer, operator, and certifying agency actions to assure continuing structural airworthiness. Author

N88-11676*# United Technologies Research Center, East Hartford, Conn.
ANALYTIC INVESTIGATION OF HELICOPTER ROTOR BLADE APPENDED AEROELASTIC DEVICES
RICHARD L. BIELAWA Feb. 1984 96 p
(Contract NAS2-11008)
(NASA-CR-166525; NAS 1.26:166525; UTRC-R84-915774-24)
Avail: NTIS HC A05/MF A01 CSCL 01C

Analytic evaluations of four different passive aeroelastic devices appended to helicopter rotor blades are presented. The devices consist of a passive tuned tab, a control coupled tab, an all-flying tip and a harmonic dilational airfoil tip. Each device was conceived for improving either aerodynamic performance or reducing vibratory control loads or hub shears. The evaluation was performed using a comprehensive rotor aeroelastic analysis (the G400PA code with appropriate modifications), together with data for a realistic helicopter rotor blade (the UH-60A Blackhawk), in high speed flight (90 m/s, 175 kts). The results of this study show that significant performance (L/(D sub e)) gains can be achieved with the all-flying free tip. Results from the harmonic dilational airfoil tip show the potential for moderate improvements in L/(D sub e). Finally, the results for the passive tuned tab and the control coupled tab, as configured for this study, show these devices to be impractical. Sections are included which describe the operation of each device, the required G400PA modifications, and the detailed results obtained for each device. Author

N88-12480*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECT OF MOTION CUES DURING COMPLEX CURVED APPROACH AND LANDING TASKS: A PILOTED SIMULATION STUDY
CHARLES H. SCANLON (Arkansas State Univ., State University.) Dec. 1987 28 p
(Contract NCC1-107)
(NASA-TP-2773; L-16351; NAS 1.60:2773) Avail: NTIS HC A03/MF A01 CSCL 01C

A piloted simulation study was conducted to examine the effect of motion cues using a high fidelity simulation of commercial aircraft during the performance of complex approach and landing tasks in the Microwave Landing System (MLS) signal environment. The data from these tests indicate that in a high complexity MLS approach task with moderate turbulence and wind, the pilot uses motion cues to improve path tracking performance. No significant differences in tracking accuracy were noted for the low and medium complexity tasks, regardless of the presence of motion cues. Higher control input rates were measured for all tasks when motion was used. Pilot eye scan, as measured by instrument dwell time, was faster when motion cues were used regardless of the complexity of the approach tasks. Pilot comments indicated a preference for motion. With motion cues, pilots appeared to work harder in all levels of task complexity and to improve tracking performance in the most complex approach task. Author

N88-12481# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
DEVELOPMENTAL AIRDROP TESTING TECHNIQUES AND DEVICES
H. J. HUNTER and R. K. BOGUE, ed. Sep. 1987 97 p
(AGARD-AG-300-VOL-6; ISBN-92-835-1559-5) Avail: NTIS HC A05/MF A01

The practical aspects of planning, conducting, and reporting on developmental airdrop tests made from cargo transport type aircraft are presented. Typical cargo aircraft aerial delivery systems, parachute extraction systems, and special devices and rigging techniques are described in detail. Typical instrumentation systems for obtaining aircraft and parachute systems force data are also described and piloting techniques for various airdrop methods are briefly discussed. A scenario of a typical parachute tow test is used to demonstrate the application of these techniques and the use of challenge and response checklists among the flight crewmembers. Finally the use of reports is discussed and appendices are included with many useful charts and calculations that are readily applicable in research and development airdrop testing. Author

N88-12482*# Sparta, Inc., Laguna Hills, Calif.
AN EVALUATION PLAN OF BUS ARCHITECTURES AND PROTOCOLS USING THE NASA AMES INTELLIGENT REDUNDANT ACTUATION SYSTEM
P. DEFEO and M. CHEN Aug. 1987 34 p
(Contract NAS2-12081)
(NASA-CR-177458; NAS 1.26:177458) Avail: NTIS HC A03/MF A01 CSCL 01C

Means for evaluating data bus architectures and protocols for highly integrated flight control system applications are needed. Described are the criteria and plans to do this by using the NASA/Ames Intelligent Redundant Actuation System (IRAS) experimental set-up. Candidate bus architectures differ from one another in terms of: topology, access control, message transfer schemes, message characteristics, initialization. data flow control, transmission rates, fault tolerance, and time synchronization. The evaluation criteria are developed relative to these features. A preliminary, analytical evaluation of four candidate busses (MIL-STD-1553B, DATAC, Ethernet, and HSIS) is described. A bus must be exercised in a real-time environment to evaluate its dynamic characteristics. A plan for real-time evaluation of these four busses using a combination of hardware and simulation techniques is presented. Author

N88-12483*# Eloret Corp., Sunnyvale, Calif.
EXPERIMENTAL AEROTHERMODYNAMIC RESEARCH OF HYPERSONIC AIRCRAFT Technical Progress Report, 1 Mar. - 30 Sep. 1987
JOSEPH W. CLEARY 9 Dec. 1987 28 p
(Contract NCC2-416)
(NASA-CR-181533; NAS 1.26:181533) Avail: NTIS HC A03/MF A01 CSCL 01C

The 2-D and 3-D advance computer codes being developed for use in the design of such hypersonic aircraft as the National Aero-Space Plane require comparison of the computational results with a broad spectrum of experimental data to fully assess the validity of the codes. This is particularly true for complex flow fields with control surfaces present and for flows with separation, such as leeside flow. Therefore, the objective is to provide a hypersonic experimental data base required for validation of advanced computational fluid dynamics (CFD) computer codes and for development of more thorough understanding of the flow physics necessary for these codes. This is being done by implementing a comprehensive test program for a generic all-body hypersonic aircraft model in the NASA/Ames 3.5 foot Hypersonic Wind Tunnel over a broad range of test conditions to obtain pertinent surface and flowfield data. Results from the flow visualization portion of the investigation are presented. Author

N88-12485# Aeronautical Research Labs., Melbourne (Australia).
HOVERING HELICOPTER FLIGHT DYNAMICS: A STUDY OF VERTICAL MOTION
C. R. GUY Feb. 1987 47 p
(AR-004-526; ARL-AERO-TM-386) Avail: NTIS HC A03/MF A01

The flight dynamic characteristics of a hovering helicopter in response to collective stick inputs are examined. A mathematical model of the aerodynamics/kinetics and rotor system dynamics of a representative aircraft, linearized about the hovering flight condition, is used as a basis for the study. The dynamic behavior of this model is compared with flight test results for similar inputs and the coefficients are adjusted to improve model performance. The model structure is then modified by the incorporation of additional terms to improve its accuracy. Although no attempt is made to optimize the coefficients of the model using parameter identification techniques, the approach used here provides acceptable results. Author

N88-12486*# Kansas Univ. Center for Research, Inc., Lawrence.
AN INTEGRATED STUDY OF STRUCTURES, AERODYNAMICS AND CONTROLS ON THE FORWARD SWEPT WING X-29A AND THE OBLIQUE WING RESEARCH AIRCRAFT Final Report
KENNETH S. DAWSON and PAUL E. FORTIN Dec. 1987 128 p
(Contract NCC2-396)
(NASA-CR-181548; NAS 1.26:181548) Avail: NTIS HC A07/MF A01 CSCL 01C

The results of an integrated study of structures, aerodynamics, and controls using the STARS program on two advanced airplane configurations are presented. Results for the X-29A include finite element modeling, free vibration analyses, unsteady aerodynamic calculations, flutter/divergence analyses, and an aeroservoelastic controls analysis. Good correlation is shown between STARS results and various other verified results. The tasks performed on the Oblique Wing Research Aircraft include finite element modeling and free vibration analyses. Author

N88-12622# Joint Publications Research Service, Arlington, Va.
A RELIABILITY CONCEPT FOR OPTIMIZING AIRCRAFT DESIGN Abstract Only
S. V. ARINCHEV and V. V. BYSTROV *In its* USSR Report: Engineering and Equipment p 1 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 7-12 Original language document was announced in IAA as A86-35977
Avail: NTIS HC A06/MF A01

A multidimensional quantile of the parameters of a system of a given order is adopted as a reliability function of the system. A lower bound on the multidimensional quantile is obtained in terms of the one-dimensional quantiles, and a relationship is established between the lower bound and the known upper bound of multidimensional probability. The possibility of using this estimate as an optimization function in flight vehicle design is illustrated through numerical modeling. Author

N88-12623# Joint Publications Research Service, Arlington, Va.
OPTIMUM TAKE-OFF RUN OF AIRCRAFT ON GROUND AIRFIELDS Abstract Only
A. A. BADYAGIN *In its* USSR Report: Engineering and Equipment p 2 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 12-16
Avail: NTIS HC A06/MF A01

Conditions under which the most favorable for take off attack angle is small were clarified. It has been alleged by another author that a drawback of this takeoff method was a rather long takeoff run, especially in the case of poor ground. Here, the opposite result was obtained: the more the resistance coefficient of ground (the poorer the ground), the larger are the optimum attack angle and the aircraft lift coefficient during takeoff. It was explained from the physical standpoint by the fact that aerodynamic wing relief not only makes it possible to realize the well known effect of reducing ground resistance forces, but also to reduce the coefficient of resistance to wheel movement. Author

N88-12625# Joint Publications Research Service, Arlington, Va.
EFFECT OF PERMISSIBLE VARIATIONS OF CENTER-OF-GRAVITY LOCATIONS OF CARGO AIRPLANE ON ITS MASS Abstract Only
V. P. GOGOLIN *In its* USSR Report: Engineering and Equipment p 4 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 24-28
Avail: NTIS HC A06/MF A01

In order to meet the requirements for stability and controllability and for the operational range of center of gravity locations, parameters of horizontal tail surfaces that determine the aft and forward limits of center-of-gravity location were chosen. At chosen parameters of the shape of airplane components, the permissible range of variations of operational center-of-gravity locations determined relationships between empennage and wing dimensions. If it is possible to narrow the range of operational center-of-gravity locations by means of design changes that require expenditures of mass (for instance, installing a fuel tank in the tail fin), the problem of determining the maximum permissible value of these expenditures comes up. This problem was solved, based on the concept of coefficients of increase of airplane mass. The derived solution was applied to a hypothetical airplane, similar, as far as its characteristics were concerned, to the TU-134 airplane. Author

N88-12626# Joint Publications Research Service, Arlington, Va.
AIRCRAFT CLASSIFICATION BY TYPE OF PROPULSIVE DEVICES. DETERMINATION OF TYPE AND NUMBER OF CARRYING SOLUTIONS Abstract Only
M. A. GURYANOV *In its* USSR Report: Engineering and Equipment p 5-6 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 33-39
Avail: NTIS HC A06/MF A01

The objective was to trace qualitative development of aircraft population and to demonstrate that in order to convert this development into a purposeful creative process it is sufficient to derive laws of formation of known kinds and types of aircraft, using the dialectic epistemology method and well studied processes of formation of populations of substances, plants and animals. The proposed method makes it possible to constantly monitor development of aircraft populations and propulsive devices. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A88-15588
SPERRY'S SOLUTION TO THE ARMY'S IDAS PROGRAM
CHRIS DELONG (Sperry Corp., Defense Systems Div., Albuquerque, NM) IN: Aerospace Avionics Equipment and Integration Conference and Exhibit, Phoenix, AZ, Apr. 23, 24, 1986, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 133-138.
(SAE PAPER 860856)

The objectives of the U.S. Army Integrated Digital Avionics System (IDAS) architecture standardization program are reviewed, and IDAS R&D efforts undertaken to upgrade the avionics of the OH-58 and OV-1 helicopters are described in detail and illustrated with extensive diagrams, drawings, and photographs. In keeping with the IDAS goal of reusing hardware and software modules, the OH-58 control and display system was adapted to the OV-1; only minor hardware modifications were required, and the use of standard display formats and data-entry procedures reduced operator retraining times. T.K.

A88-16448
AIRCRAFT CONTROL AND NAVIGATION SYSTEM FOR L 610 AIRCRAFT
STANISLAV CEKAL and MILAN KUBAT Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1987, p. 231-233. In Czech.

The control and navigation system being developed for the L 610 aircraft consists of three computers which ensure the aircraft navigation, the indication of critical flight situations, and the autopilot functions. The paper describes the functions of the individual computers and presents the individual modules housing the instruments. Author

N88-11659# Royal Aircraft Establishment, Bedford (England). Flight Systems Div.
THE FLIGHT EVALUATION OF AN ADVANCED ENGINE DISPLAY AND MONITORING SYSTEM
L. ADAMS *In* AGARD, Rotorcraft Design for Operations 10 p Jun. 1987
Avail: NTIS HC A14/MF A01

A Wessex helicopter was used to develop and evaluate a suite of advanced, integrated avionics. An important area of study was concerned with the display of engine and transmission data, and with a system monitor which gives audio and visual warning of any problems. The system demonstrated that the suppression of engine and transmission data at all times except when the pilot

asks for it to be displayed or the system detects a problem is an acceptable technique. Author

N88-11671# Societe Nationale Industrielle Aerospatiale, Marignane (France). Div. Helicoptere.
SYSTEM FOR SAR MISSIONS [SYSTEME DE MISSION SAR]
S. RIOCHE *In* AGARD, Rotorcraft Design for Operations 10 p Jun. 1987 In FRENCH
Avail: NTIS HC A14/MF A01

The helicopter division of Aerospatiale developed a specially adapted system for search and rescue (SAR) missions at sea. The system allows entirely automatic piloting and guidance, particularly during the execution of search patterns and the descent to hovering flight in the proximity of the target. An electronic flight instrument system (EFIS) panel includes cathode screen displays for attitude, horizontal situation parameters, and search radar data. The horizontal situation parameters are selected as a function of the phase of flight from four modes: horizontal situation indicator, sector with or without superimposed radar data, search pattern, and hover. M.G.

N88-11677# European Space Agency, Paris (France).
THE AVIONICS FLIGHT EVALUATION SYSTEM (AFES) OF THE DFVLR
KARLHEINZ HURRASS and PETER SCHULZ Jul. 1987 87 p Transl. into ENGLISH of Das Avionik-Flugprobungssystem (AFES) der DFVLR (Brunswick, Federal Republic of Germany) Original language document was previously announced as N85-27864
(ESA-TT-1037; DFVLR-MITT-85-01; ETN-87-91116) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, Cologne, Federal Republic of Germany DM 23

A real time avionics flight evaluation system using a laser radar unit instead of recording theodolites was designed. The inertial navigation system on board the test platform, the tracking radar, and sensors are integrated via a Kalman filter by a computer in the test aircraft. Before the measurement results of the ground sensors are up linked to the aircraft, they are preprocessed in a computer belonging to the radar units. Accuracies of up to 0.1 m for position and up to 0.01 m/sec for velocity are achieved in determining the reference flight path. Determination of the reference data is almost continuous. Multipath propagation disturbance factor is measured by a subsystem. Another subsystem simulates a particular number of users of a navigation system. ESA

N88-12487*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF COMBINING VERTICAL AND HORIZONTAL INFORMATION INTO A PRIMARY FLIGHT DISPLAY
TERENCE S. ABBOTT, MARK NATAUPSKY, and GEORGE G. STEINMETZ Dec. 1987 21 p
(NASA-TP-2783; L-16366; NAS 1.60:2783) Avail: NTIS HC A03/MF A01 CSCL 01D

A ground-based aircraft simulation study was conducted to determine the effects of combining vertical and horizontal flight information into a single display. Two display configurations were used in this study. The first configuration consisted of a Primary Flight Display (PFD) format and a Horizontal Situation Display (HSD) with the PFD displayed conventionally above the HSD. For the second display configuration, the HSD format was combined with the PFD format. Four subjects participated in this study. Data were collected on performance parameters, pilot-control inputs, auditory evoked response parameters (AEP), oculometer measurements (eye-scan), and heart rate. Subjective pilot opinion was gathered through questionnaire data and scorings for both the Subjective Workload Assessment Technique (SWAT) and the NASA Task Load Index (NASA-TLX). The results of this study showed that, from a performance and subjective standpoint, the combined configuration was better than the separate configuration. Additionally, both the eye-transition and eye-dwell times for the separate HSD were notably higher than expected, with a 46% increase in available visual time when going from double to single display configuration. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A88-14279#
HIGH MACH PROPULSION SYSTEM INSTALLATION AND EXHAUST SYSTEM DESIGN CONSIDERATIONS
D. J. DUSA (General Electric Co., Cincinnati, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 6 p.
(AIAA PAPER 87-2941)

The prospects that have emerged for the development of efficient powerplants operating in the Mach 3-6 regime, for both commercial transport aircraft and military aircraft, are presently evaluated in view of the last decade's advancements in aircraft gas turbine engine technology. Attention is given to exhaust nozzle component technology readiness issues associated with the use of such exotic fuels as hydrogen and methane, on the one hand, and the generally far higher operating temperatures that will be encountered, on the other. While turbofan cycles are preferred below Mach 4, a dual-mode turboramjet will be needed for the Mach 4-6 regime. O.C.

A88-15032
FAULT DETECTION - DIAGNOSIS AND PREDICTIVE MAINTENANCE
ANDRE RAULT and CHRYSOSTOME BASKIOTIS (ADERSA, Verrieres-le-Buisson, France) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 1593-1597. refs

The general principles of fault detection, diagnosis, and predictive maintenance are presented. The diagnosis methodology is analyzed for two jet-engine applications: the Marbore single-spool engine and the Larzac twin-spool engine. The Larzac example shows that, among the performance analysis parameters, the dynamic ones are better for fault detection. It is also shown that the methodology has to be adaptive and progressive as the learning population cannot be complete; a specific measure of the degree of membership of a newcomer to the incomplete classes has been developed and its efficiency has been demonstrated for the Marbore engine. B.J.

A88-15380
JUMPING JET POWER FOR THE NEXT CENTURY
CHARLES GILSON Interavia (ISSN 0020-5168), vol. 42, Oct. 1987, p. 1033-1036.

There is as yet no stated requirement for a supersonic dash-capable, advanced STOVL combat aircraft that would serve as a replacement for the current Harrier/Sea Harrier/Harrier II aircraft in U.S. and British inventories; nevertheless, conceptual studies are proceeding which have as their general design reference-point a single-engined air superiority fighter with supersonic capability only to about Mach 1.6. Attention is presently given to propulsion system configurations involving thrust vectoring with plenum chamber burning, remote augmented lift, ejector-augmented lift, and tandem-fan turbofans. Payload/range and maneuverability are required to be comparable to those of the EFA and Rafale fighters. O.C.

A88-15527*#
HYDROGEN SCRAMJET WITH SIDE WALL INJECTION
R. G. MORGAN, A. PAULL, N. MORRIS, and R. J. STALKER IN: National Space Engineering Symposium, 2nd, Sydney, Australia, Mar. 25-27, 1986, Preprints. Volume 2. Barton, Australia/Brookfield, VT, Institution of Engineers, Australia/Brookfield Publishing Co., 1986, 10 p refs
(Contract NAGW-674)

Preliminary results are presented from an experimental evaluation of a hydrogen-burning wall-injection scramjet engine, performed in the free-piston shock tunnel at the Australian National University. The advantages of scramjet propulsion for high-Mach-number high-altitude flight are reviewed, and the need for an alternative to injection struts is indicated. Pressure profiles and heat-transfer measurements for constant-area and diverging ducts are presented graphically and characterized in detail. The ability of the injected flow to shield the chamber wall from the heat of the freestream flow is demonstrated. The extrapolation of the shock-tunnel results to flight conditions, however, is made difficult by the fact that a significant amount of fuel passes through a quenched zone without burning, seriously degrading overall performance. T.K.

A88-15978#
COMBINED CYCLE PROPULSION FOR HYPERSONIC FLIGHT
DAVID L. KORS (Aerojet TechSystems Co., Sacramento, CA) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 11 p. refs
(IAF PAPER 87-263)

During the two decades from 1965 to 1985, hypersonic airbreathing propulsion underwent only token research, which has nevertheless yielded a very substantial data base for post-1985 efforts toward combined rocket/airbreathing propulsion cycles. Attention is presently given to configurations variously derived from the integration of generic turbojet, ramjet, and rocket technologies, yielding turboramjets, turboramjet-rockets, turborockets, ducted rockets, ejector ramjets, and supercharged ejector ramjets. The advantages of scramjets are discussed in the framework of their aerodynamic configuration integration requirements. O.C.

A88-16728
NEW DEVELOPMENTS OF EUROPEAN POWERPLANTS FOR HELICOPTERS; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, OCT. 21, 1986
London, Royal Aeronautical Society, 1986, 127 p. For individual items see A88-16729 to A88-16734.

This symposium report includes papers on two new power plants for helicopters, the TM 333 and TM 319 turboshafts; the MTM 385 engine; and the RTM 322 turboshaft engine. Other papers presented are on RTM 322 electronic control and anticipated developments, the TM 319 and TM 333 electonic control design and operational features, propulsion aspects of achieving high speed with helicopters, and airworthiness requirements for new engine ratings for helicopters. I.S.

A88-16729
TM 333 AND TM 319 TURBOSHAFTS - TWO NEW POWERPLANTS FOR HELICOPTERS
JOEL SILET (Turbomeca, S.A., Bordes, France) IN: New developments of European powerplants for helicopters; Proceedings of the Symposium, London, England, Oct. 21, 1986 . London, Royal Aeronautical Society, 1986, p. 1-14.

The first two engines (TM 333 and TM 319) of a new generation of helicopter powerplanes which will cover the 450 to 2400 shp range are described. The design features of the TM 333 and TM 319 are described, and the cross sections are presented. Consideration is also given to the engines' Full Authority Digital Electronic Control system, similar for both engines, and to the installation features. Data on the engine performance, maintenance, and reliability are also given. The salient features of the two new-generation engines include high performance levels, modular and easy maintenance, easy installation, a numerical electronic fuel control system that operates and optimizes the performance in a large flight envelope, and a large growth potential. I.S.

A88-16730
MTM385 ENGINE
K. TRAPPMANN (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) IN: New developments of European powerplants for helicopters; Proceedings of the Symposium, London, England, Oct. 21, 1986 . London, Royal Aeronautical Society, 1986, p. 15-38.

The MTM 385 R2, the latest version of the MTM 385 engine designated for the future twin-engine French-German combat helicopter HAP/PAH2/HAC3G is described together with the design and functional characteristics of the engine's components. The engine design requirements include the take-off power of 749 kW (at 1000m and 25 C), 30-s emergency power of 998 kW (at 1500 m), and acceleration of 3 s (0-100 percent power). Tests carried out on the engine's reverse-flow combustion chamber and single-stage transonic compressor turbine, as well as on two demonstrator engines, showed that the majority of the program objectives were attained. I.S.

A88-16731
THE RTM 322 TURBOSHAFT ENGINE
P. V. LANGDELL and O. R. ESPITALIER-NOEL (Rolls-Royce, PLC, Watford, England) IN: New developments of European powerplants for helicopters; Proceedings of the Symposium, London, England, Oct. 21, 1986 . London, Royal Aeronautical Society, 1986, p. 39-58.

The RTM 322, a turboshaft engine in the 2000-3000 shp class designated to fill the needs of collaborative European helicopter programs, is described. The high level of performance required by the engine is achieved with a cycle based on a modest pressure ratio, low turbine temperatures, and engine characteristics optimized for part power. A single spool gas generator is used with three-stage axial plus centrifugal compressor, and a compact reverse-flow combustor is used for minimum spool length; a two-stage turbine drives the compressor system. The RTM 322-01 has an overall pressure ratio of 14.7 and a turbine entry temperature of less than 1500 K. The engine has already demonstrated 2400 shp on the test bed. I.S.

A88-16732
RTM322 ELECTRONIC CONTROL AND ANTICIPATED DEVELOPMENTS
D. A. HAIGH and J. TIPTON (Lucas Aerospace, Ltd., Electronic Systems and Equipment Div., Birmingham, England) IN: New developments of European powerplants for helicopters; Proceedings of the Symposium, London, England, Oct. 21, 1986 . London, Royal Aeronautical Society, 1986, p. 59-77.

The electronic control unit designed for the RTM 322 turboshaft engine is described. Attention is given to the system architecture, mounting location, programming language, packaging technology, and interface designs, as well as to the thermal considerations, the EMC design principles, and the design features of the main control channel. The salient features of the control unit's flexible modular software system LUCOL are discussed and compared to those of Ada. The design diagrams are included. I.S.

A88-16733
TM 319 AND TM 333 ELECTRONIC CONTROL DESIGN AND OPERATIONAL FEATURES
J. LUC LARRERE (Elecma, Suresnes, France) IN: New developments of European powerplants for helicopters; Proceedings of the Symposium, London, England, Oct. 21, 1986 . London, Royal Aeronautical Society, 1986, p. 78-93.

The single-lane full-authority digital electronic control unit designed for the turboshaft engines TM 319 and TM 333 is described. The control unit is a microprocessor-based system made of three subassemblies: a power supply module, a set of stacked racks, and an interconnection module. The control unit controls the free turbine speed through the fuel flow into the gas generator, ensures the free turbine overspeed protection, and controls the

position of the variable inlet guide vanes. The critical functions are backed up by self-testing analog systems which are surveyed by the main channel. Diagrams depicting the architecture of the control unit are included. I.S.

A88-16734
AIRWORTHINESS REQUIREMENTS FOR NEW ENGINE RATINGS FOR HELICOPTERS
P. D. VINALL (Civil Aviation Authority, Surrey, England) IN: New developments of European powerplants for helicopters; Proceedings of the Symposium, London, England, Oct. 21, 1986 . London, Royal Aeronautical Society, 1986, p. 94-119.

he airworthiness requirements for new helicopter-engine ratings are examined. Current helicopter ratings are discussed and compared with new helicopter rating structures, in which the new 30-sec power plus 2-min power in events of engine balking replace the existing maximum contingency. The new Type Endurance testing proposed by AIA and the test requirements proposed by CAA are discussed. In order to bridge the gulf between the two proposals, a modified set of tests is suggested, termed the Flexible Proposal. The testing specifications under the Flexible Proposal are compared to those of the CAA proposal. I.S.

A88-16902#
APPLICATION OF A FUZZY CONTROLLER IN FUEL SYSTEM OF TURBOJET ENGINE
QIHUA WU, YUNHUA XU, and BENWEI LI (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), Oct. 1987, p. 23-30. refs

The fundamental principles and practical techniques of fuzzy-control design are discussed, and a fuzzy control for a jet-engine fuel system is developed and tested. The conventional membership-degree calculation method and the phase-plane graphic method of Li (1983) are shown to share the same theoretical basis, and the latter method is found to be more convenient for adjusting simple fuzzy-control rules. The effectiveness of the fuzzy controls developed is demonstrated by means of computer simulations; the results are presented in graphs. T.K.

N88-11679*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TEST STAND PERFORMANCE OF A CONVERTIBLE ENGINE FOR ADVANCED V/STOL AND ROTORCRAFT PROPULSION
JACK G. MCARDLE 1987 22 p Presented at the International Powered Lift Conference, Santa Clara, Calif., 7-10 Dec. 1987; sponsored by the Society of Automotive Engineers
(NASA-TM-100211; E-3819; NAS 1.15:100211) Avail: NTIS HC A03/MF A01 CSCL 21E

A variable inlet guide vane (VIGV) convertible engine that could be used to power future high-speed V/STOL and rotorcraft was tested on an outdoor stand. The engine ran stably and smoothly in the turbofan, turboshaft, and dual (combined fan and shaft) power modes. In the turbofan mode with the VIGV open, fuel consumption was comparable to that of a conventional turbofan engine. In the turboshaft mode with the VIGV closed, fuel consumption was higher than that of present turboshaft engines because power was wasted in churning fan-tip air flow. In dynamic performance tests with a specially built digital engine control and using a waterbrake dynamometer for shaft load, the engine responded effectively to large steps in thrust command and shaft torque. Author

N88-12488# Science and Engineering Associates, Inc., Seattle, Wash.
AIRCRAFT ENGINE EXHAUST PLUME DYNAMICS Final Report, Dec. 1984 - Aug. 1985
B. T. DELANEY, BRYAN A. ZETLEN, RONALD C. TAI, GLENN D. SEITCHEK, and G. G. ELCOCK Oct. 1986 31 p
(Contract F08635-85-C-0036)
(AD-A184238; AFESC/ESL-TR-86-20) Avail: NTIS HC A03/MF A01 CSCL 21B

This report summarizes a research effort to remedy a known deficiency in the Air Quality Assessment Model dispersion calculation capability. Current methods use dispersion calculations and equations for vertical sources (i.e., power plants) resulting in inaccurate assumptions when applied to the horizontal source of an aircraft engine. This study examined the dispersion of aircraft engine exhaust by using infrared thermal imaging techniques. These results were compared to theoretical equations describing jet exhaust plumes. The resulting validation provided the necessary equations and support to mathematically model this phenomena. GRA

N88-12490*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE AND COMBUSTION CHARACTERISTICS OF DIRECT-INJECTION STRATIFIED-CHARGE ROTARY ENGINES
HUNG LEE NGUYEN Dec. 1987 29 p
(NASA-TM-100134; E-3684; NAS 1.15:100134) Avail: NTIS HC A03/MF A01 CSCL 21A

Computer simulations of the direct-injection stratified-charge (DISC) Wankel engine have been used to calculate heat release rates and performance and efficiency characteristics of the 1007R engine. Engine pressure data have been used in a heat release analysis to study the effects of heat transfer, leakage, and crevice flows. Predicted engine performance data are compared with experimental test data over a range of engine speeds and loads. An examination of methods to improve the performance of the Wankel engine with faster combustion, reduced leakage, higher compression ratio, and turbocharging is presented. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A88-13430#
EXPERIENCE WITH NASA-LANGLEY TECHNOLOGY FOR A FREE-FLYING MODEL IN A WIND TUNNEL [ERFAHRUNGEN MIT DER NASA-LANGLEY-TECHNIK EINES FREIFLIEGENDEN MODELLS IM WINDKANAL]
HELMUT JOHN (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 99-110. In German.

Experimental results on a new technology for a free-flying model conducted in a subsonic wind tunnel are reported. An ejector driven by a loosely connected supply line is used in the thrust simulation. As well as being flown freely, the model can be steered about three axes using a simplified steering system and three 'ministicks'. The technology permits studies in the separated flow region and in the present case up to an angle of 90 deg. C.D.

A88-14018#
THE INFLUENCE OF UNSTEADY AERODYNAMIC FORCES ON DYNAMIC RESPONSE OF A VARIABLE SWEEP AIRCRAFT
MING YAN, WENBO ZHOU, XIANGHAI SUN, ZHEN YAN (Jiaotong University, Shanghai, People's Republic of China), and CHUANREN QIU (Shanghai Aircraft Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Sept. 1987, p. 261-270. In Chinese, with abstract in English. refs

A88-14259*# *Grumman Aerospace Corp., Bethpage, N.Y.*
X-29A FLIGHT CONTROL SYSTEM PERFORMANCE DURING FLIGHT TEST
J. CHIN (Grumman Aerospace Corp., Aircraft Systems Div., Bethpage, NY), V. CHACON, and J. GERA (NASA, Flight Research Center, Edwards, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 13 p. refs
(AIAA PAPER 87-2878)

An account is given of flight control system performance results for the X-29A forward-swept wing 'Advanced Technology Demonstrator' fighter aircraft, with attention to its software and hardware components' achievement of the requisite levels of system stability and desirable aircraft handling qualities. The Automatic Camber Control Logic is found to be well integrated with the stability loop of the aircraft. A number of flight test support software programs developed by NASA facilitated monitoring of the X-29A's stability in real time, and allowed the test team to clear the envelope with confidence. O.C.

A88-14260#
FLIGHT CONTROL SYNTHESIS TO MEET FLYING QUALITIES SPECIFICATIONS - AN EVALUATION OF MULTIVARIABLE SYNTHESIS TECHNIQUES
THOMAS R. WENDEL (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 11 p. refs
(AIAA PAPER 87-2880)

Four different multivariable model-following design techniques were evaluated to assess their applicability to the flight control law design of advanced aerospace vehicles. The ability of these synthesis techniques to meet the flying qualities, robustness, and turbulence rejection requirements of future fighter aircraft within the deflection and rate constraints of the actuation system was examined. The gain scheduling required to implement the control laws developed by these synthesis techniques was also investigated and the manpower required to formulate a control system capable of meeting the chosen design objectives was evaluated. This evaluation identified strengths and weaknesses of the techniques and established effective ways of applying these algorithms to the design of 'real world' high order control systems. It was determined that these algorithms can meet flying qualities requirements of advanced fighter aircraft while satisfying stability margin and turbulence rejection requirements. However, the ability of these algorithms to effectively manage high order dynamics such as actuator dynamics, sensor dynamics and structural filters should be improved. Author

A88-14277*# Kansas Univ., Lawrence.
AN ANALYSIS OF A CANDIDATE CONTROL ALGORITHM FOR A RIDE QUALITY AUGMENTATION SYSTEM
REINER SUIKAT, KENT DONALDSON, and DAVID R. DOWNING (Kansas, University, Lawrence) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 9 p. refs
(Contract NAG1-345)
(AIAA PAPER 87-2936)

This paper presents a detailed analysis of a candidate algorithm for a ride quality augmentation system. The algorithm consists of a full-state feedback control law based on optimal control output weighting, estimators for angle of attack and sideslip, and a maneuvering algorithm. The control law is shown to perform well by both frequency and time domain analysis. The rms vertical acceleration is reduced by about 40 percent over the whole mission flight envelope. The estimators for the angle of attack and sideslip avoid the often inaccurate or costly direct measurement of those angles. The maneuvering algorithm will allow the augmented airplane to respond to pilot inputs. The design characteristics and performance are documented by the closed-loop eigenvalues; rms levels of vertical, lateral, and longitudinal acceleration; and representative time histories and frequency response. Author

A88-14311
RESEARCH ON AIRSHIP FLIGHT DYNAMICS AT THE UNIVERSITY OF TORONTO
JAMES D. DELAURIER, JAMES D. LOWE, DONALD R. UFFEN, and JUSTIN H. AMANN (Toronto, University, Downsview, Canada) IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 14.1 to 14.47. refs

An account is given of the most important results obtained in the course of studies concerning the stability, control, and atmospheric turbulence behavior of historic and contemporary airships encompassing both conventional configurations and certain 'heavy lift' designs. Theoretical investigations such as linearized stability prediction analyses have been conducted, together with nonlinear computerized simulations of long-duration control in gust response. Experimental work has extended to wind tunnel tests and flight tests of dynamically-scaled radio-controlled models. These research techniques have been applied to the design of a small, low fineness ratio blimp. O.C.

A88-14939
REDUCED ORDER VARIABLE STRUCTURE CONTROL OF THE LATERAL MOTION OF AN AIRCRAFT
B. A. WHITE (Royal Military College of Science, Shrivenham, England), R. J. PATTON, S. MUDGE, and P. P. ASLIN (York, University, England) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 322-327. refs

This paper looks at the application of Variable Structure Control (VSC) theory to the problem of lateral control of a Machan aircraft. A full state switching VSC system is developed and is shown to produce dynamic responses in roll and yaw which are functions of pitch and roll angle. A reduced state switching VSC system is subsequently defined to produce a more invariant performance. Author

A88-14960
FLIGHT CONTROL OF AN X-29 TYPE AIRCRAFT VIA A COMBINATION OF LQ OPTIMIZATION TECHNIQUES
R. MARIE and E. KREINDLER (Technion - Israel Institute of Technology, Haifa) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 656-660. refs

The longitudinal flight control of a forward-swept-wing, inherently unstable aircraft with significant wing aeroelasticity is considered, using implicit model following to design handling qualities and frequency weighting to damp the aeroelastic modes. The former technique introduces into the performance index the equations of a model embodying the desired closed-loop characteristics; the latter has frequency-dependent weighting parameters in the index, thereby introducing dynamics into the state feedback. For the design problem at hand, the two techniques turned out to be complemetary; a combination which exploits the advantages of both was successful. Author

A88-14961
A DECOUPLING APPROACH TO THE DESIGN OF THE TWO-DEGREE-OF-FREEDOM TRACKING CONTROL SYSTEMS
E. SOROKA and U. SHAKED (Tel Aviv University, Israel) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 661-665. refs

A general new decoupling configuration of the two-degree-of-freedom tracking control system is presented. In this configuration the closed loop part, that satisfies the regulation requirements, and the prefilter part, that yields the desired command response, can be found independently one from the other. When implemented, each part of the controller does not interfere with the response characteristics that were shaped by the other part. The developed theory is shown to provide a new general conceptual approach for the design of linear tracking control systems. The theory is applied in a design of nominal and decoupled flight control modes of the Control Augmentation System (CAS) for fighter aircrafts. Author

A88-14965
A NUMERICAL APPROACH FOR ON-LINE GUIDANCE OF AIRCRAFT
WERNER GRIMM (DFVLR, Institut fuer Dynamik der Flugsysteme, Wessling, Federal Republic of Germany) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 683-687. refs

A numerical procedure for flight path optimization in real time is presented. The optimal control problems are solved relative to a reduced version of the state equations, assuming that flight path inclination and heading angle are directly controllable. Two basic concepts make the method fast and robust, and therefore make it feasible for on-line implementation: (1) the replacement of expensive numerical integration by a special integrator for the reduced ODE system; and (2) the adaptation of state constraints in such a way that they can be satisfied by analytical elimination of parameters. The algorithm is tested on two problems: range maximization and minimum-time intercept; and a comparison with open-loop trajectories shows that the proposed feedback control is highly accurate. B.J.

A88-14978
APPLICATION OF ROBUST DIRECT ADAPTIVE CONTROL TO THE LONGITUDINAL DYNAMICS OF A FIGHTER AIRCRAFT
K. M. SOBEL, H. P. LEE (Lockheed-California Co., Burbank), and P. IOANNOU (Southern California, University, Los Angeles, CA) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 844, 845. Research supported by Lockheed-Georgia Co. refs

This paper investigates the use of a robust direct adaptive controller (RDAC) for controlling the linearized time varying dynamics of the longitudinal motion of an F-16 aircraft and compares its performance with that of gain scheduling and fixed controller schemes. Four different control schemes are simulated and their performance is compared for different input commands over a complete flight envelope. The simulation results show that the control schemes which employ the RDAC perform much better than the fixed and gain scheduling control schemes. Author

A88-15033
STUDY OF THE EFFECTS OF DISCRETIZING QUANTITATIVE FEEDBACK THEORY ANALOG CONTROL SYSTEM DESIGNS
J. S. COUCOULES, C. H. HOUPIS (USAF, Institute of Technology, Wright-Patterson AFB, OH), and G. B. LAMONT (Wright State University, Dayton, OH) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 1603-1608. refs

An analysis is made of the feasibility of using the pseudo continuous time (PCT) modeling approach for a sampled-data system in extending continuous domain (analog) quantitative feedback theory (QFT) flight control system designs to the discrete domain. The results of two analog designs are studied for digital implementation. Simulation results for a transport aircraft show that the Tustin transformation with PCT modeling provides good results using a sampling rate of 40 Hz. In addition, results are obtained with a sampling rate of 60 Hz for a fighter aircraft. It is concluded that the Tustin transformation with PCT modeling provides good discrete system performance in transforming the continuous QFT design for a variety of operational modes. B.J.

A88-16335#
THE ON-LINE IDENTIFICATION AND ITS MICROPROCESSOR REALIZATION OF THE EQUIVALENT SYSTEMS OF AIRCRAFT
FENG LIANG and LINCHANG ZHANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, May 1987, p. A296-A302. In Chinese, with abstract in English.

A new method is proposed in this paper to use a microprocessor system to evaluate the flight qualities of aircraft. The extended Kalman filtering algorithm (EKF) is used to estimate the parameters of the discrete model of longitudinal equivalent systems. Some new improvements are made for EKF algorithm to prevent divergence of estimated parameters and to reduce the estimating errors. The algorithm will converge to a local minimum because of the reduced order approximation. Satisfactory accuracy of parameter estimation and fast convergent rates have been achieved by both digital simulation calculation and microprocessor system experiments using arbitrary input signals. The experimental system works stationarily and has good repeatable characteristics. Author

A88-16342#
DEVELOPMENT OF MANEUVER LOADS SPECTRUM FOR X-TYPE AIRCRAFT
SHUNQI HUANG (China Flight Test Research Center, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, June 1987, p. B291-B294. In Chinese, with abstract in English.

This paper describes an approach for obtaining a maneuver load spectrum for an X-type aircraft using the flight-by-flight spectrum method. First of all, the mission segment spectra are developed based on the typical mission profiles; then the mission spectra and the maneuver spectrum are derived. The maneuver spectrum is compared with the load spectra of several types of aircraft. Author

A88-16555*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MECHANISMS OF ACTIVE CONTROL IN CYLINDRICAL FUSELAGE STRUCTURES
R. J. SILCOX, H. C. LESTER (NASA, Langley Research Center, Hampton, VA), and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 11 p. refs (AIAA PAPER 87-2703)

This paper summarizes ongoing efforts to understand and exploit active control techniques for low frequency noise suppression in aerospace applications. Analytical models are utilized in an effort to understand the mechanisms that govern noise transmission into acoustic spaces enclosed by lightweight structures and to examine the results of experimental implementations of active control schemes. Emphasis is placed on attaining global noise reductions using a minimum number of actuators rather than localized control over many subregions. This program has demonstrated the effect of synchrophasing and interface modal filtering, in limiting the modal density within the acoustic space, and how strong reactive effects may occur in two dimensional geometries. Finally, the performance of active control systems utilizing acoustic and vibration actuators is evaluated. Suppressions of 10 to 30 dB are demonstrated in practice, and performance is discussed in relation to the physical mechanisms and parameters of the system. Author

N88-11653# National Aeronautical Establishment, Ottawa (Ontario). Flight Research Lab.
INVESTIGATION OF VERTICAL AXIS HANDLING QUALITIES FOR HELICOPTER HOVER AND NOE FLIGHT
S. W. BAILLIE and J. M. MORGAN *In* AGARD, Rotorcraft Design for Operations 9 p Jun. 1987 Sponsored in part by Canadian Department of National Defense
Avail: NTIS HC A14/MF A01

The preliminary results of two in-flight simulation programs on vertical axis rotorcraft handling qualities are presented. The parameters investigated in these studies were heave damping, thrust to weigh ratio (T/W), and a number of dynamic engine governor/rotor system models. Flight tasks include hover, hover maneuvering and nap of the Earth (NOE) flight. Evaluation of nine heave damping, thrust to weight ratio configurations provides the basis to suggest Level 1 Z sub w and T/W boundary values of -0.20 sec -1 and 1.08 respectively. These boundaries are compared with other relevant work on the topic. The engine governor/rotor system evaluation results tend to disagree with handling qualities predictions based on a vertical velocity shaping parameter. Author

N88-11654# Systems Technology, Inc., Hawthorne, Calif.
HANDLING QUALITIES CRITERION FOR VERY LOW VISIBILITY ROTORCRAFT
ROGER H. HOH *In* AGARD, Rotorcraft Design for Operations 15 p Jun. 1987
Avail: NTIS HC A14/MF A01

This research was conducted to investigate the required visual cueing for low speed and hover and to determine if an increase in stabilization can effectively be used to compensate for the loss of essential cues. Two flight test experiments were conducted using a conventional helicopter and a variable stability helicopter, as well as electronically fogged lenses and night vision goggles with daylight training filters. The primary conclusion regarding the essential cues for hover was that fine grained texture is more important than large discrete objects or field of view. The use of attitude command augmentation was found to be effective as a way to make up for display deficiencies. However, a corresponding loss of agility occurred with the tested attitude command/attitude hold system resulting in unfavorable pilot comments. Hence, the favorable control display tradeoff must be interpreted in the context that the best solution would be to improve the vision aid. Such an improvement would require an increase in the visual microtexture, an advancement in display technology that is unlikely to be available in the foreseeable future. Therefore, a criterion was developed to systematically evaluate display quality and the associated upgrade in required stabilization as a function of increasingly degraded visual cues. Author

N88-11660# Societe Nationale Industrielle Aerospatiale, Marignane (France). Dept. Systemes.
ACTIVE CONTROL OF HELICOPTER VIBRATION USING MULTILOOP SELF-ADAPTIVE CONTROL [CONTROLE ACTIF DES VIBRATIONS SUR HELICOPTERE PAR COMMANDS MULTICYCLIQUES AUTOADAPTATIVES]
MARC ACHACHE and MICHEL GAUVRIT (Centre d'Etudes et de Recherches, Toulouse, France) *In* AGARD, Rotorcraft Design for Operations 10 p Jun. 1987 In FRENCH
Avail: NTIS HC A14/MF A01

A research program for the development of a trial multiloop control system for the active control of vibration in the main rotor blades is described. This experimentation consists of the most significant applications of self-adaptive control techniques to stochastic systems. The various stages of the program are discussed, from the research on the theoretical model of helicopter vibratory behavior under the influence of multiloop control, to the system flight tests. M.G.

N88-11661# Textron Bell Helicopter, Fort Worth, Tex.
CONTROLLING THE DYNAMIC ENVIRONMENT DURING NOE FLIGHT
DENNIS R. HALWES *In* AGARD, Rotorcraft Design for Operations 9 p Jun. 1987
Avail: NTIS HC A14/MF A01

A six degree-of-freedom isolation system using six Liquid Inertia Vibration Eliminator (LIVE) units was installed on a Bell 206LM helicopter. The system was named the Total Rotor Isolation System (TRIS). To determine the effectiveness of TRIS in reducing helicopter vibrations, a flight verification syudy was conducted. The objective was to demonstrate a 90 percent (or greater) isolation of the helicopter fuselage from the main rotor forces and moments transmitted at the blade passage frequency, which is 4/rev in the case of the Bell 206LM. The flight test data indicate that the objectives were surpassed. Author

N88-11662# Westland Helicopters Ltd., Yeovil (England).
MINIMISATION OF HELICOPTER VIBRATION THROUGH ACTIVE CONTROL OF STRUCTURAL RESPONSE
S. P. KING and A. E. STAPLE *In* AGARD, Rotorcraft Design for Operations 13 p Jun. 1987
Avail: NTIS HC A14/MF A01

The current demonstration and installation of the Active Control Structural Response (ACSR) technique on a Westland 30 helicopter is discussed. The technique employs high frequency force actuation within the helicopter's structure. These forces are superposed onto the dominant vibratory forces in an active manner, such that the fuselage vibratory response is minimized. The basic control philosophy for ACSR is described and the current experimental demonstration status is detailed. Author

N88-11680*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLIGHT PROPULSION CONTROL INTEGRATION FOR V/STOL AIRCRAFT
JAMES R. MIHALOEW 1987 22 p Presented at the International Powered Lift Conference, Santa Clara, Calif., 7-10 Dec. 1987; sponsored by the Society of Automotive Engineers
(NASA-TM-100226; E-3845; NAS 1.15:100226) Avail: NTIS HC A03/MF A01 CSCL 01C

The goal of the propulsion community is to have the enabling propulsion technologies in place to permit a low risk decision regarding the initiation of a research STOVL supersonic attack fighter aircraft in the mid-1990's. This technology will effectively integrate, enhance, and extend the supersonic cruise, STOVL, and fighter/attack programs to enable U.S. industry to develop a revolutionary supersonic short takeoff vertical landing fighter/attack aircraft in the post-ATF period. The rationale, methods, and criteria used in developing a joint NASA Lewis and NASA Ames research program to develop the technology element for integrated flight propulsion control through integrated methodologies is presented. This program, the Supersonic STOVL Integrated Flight Propulsion Controls Program, is part of the overall NASA Lewis Supersonic STOVL integrated approach to an integrated program to achieve integrated flight propulsion control technology. Author

N88-12492# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
ENGINE/AIRFRAME RESPONSE EVALUATION OF THE HH-60A HELICOPTER EQUIPPED WITH THE T700-GE-701 TRANSIENT DROOP IMPROVEMENT ELECTRONIC CONTROL UNIT Final Report, 9 Jun. - 25 Aug. 1987
GARY L. BENDER, JAMES A. ADKINS, and ROY A. LOCKWOOD Oct. 1986 79 p
(AD-A184443; USAAEFA-86-02) Avail: NTIS HC A05/MF A01 CSCL 01C

The engine/drive train response was stable for all tests performed. The best configuration for magnitude of main rotors speed droop, rotor speed/power turbine speed droop recovery characteristics, and power turbine speed governing characteristics was the HH-60A with the T700-GE-401 engines equipped with the -401 transient droop improvement engine control unit. The

HH-60A with the T700-GE-401 engine equipped with the -701 transient droop improvement engine control unit (with and without the collective potentiometer input) exhibited larger rotor speed droop, noticeable drive train oscillation during droop recovery, and less desirable power turbine speed governing characteristics. The undesirable engine/airframe characteristics of the HH-60A with the -701 transient droop improvement engine control unit is a shortcoming. The UH-60A with the T700-GE-700 engine demonstrated the largest main rotor speed droop but residual drive train oscillations were small, droop recovery characteristics were more predictable and power turbine speed governing was noticeably more stable than demonstrated by the T700-GE0-401 engines equipped with the -701 transient droop improvement engine control unit. The undesirable engine/airframe response (large main rotor speed droop) of the UH-60A with the T700-GE-700 engines is a previously identified shortcoming. Future designs for the UH-60 engine control units should include all the transient droop improvements of the -401 transient droop improvement engine control unit. Additionally, future designs of engine control units should have dynamics tailored to the particular helicopter in which the engines are to be installed. GRA

N88-12493*# Systems Technology, Inc., Mountain View, Calif.
SOME DATA PROCESSING REQUIREMENTS FOR PRECISION NAP-OF-THE-EARTH (NOE) GUIDANCE AND CONTROL OF ROTORCRAFT
WARREN F. CLEMENT, DUANE T. MCRUER, and RAYMOND E. MAGDELENO Feb. 1987 224 p
(Contract NAS2-12364)
(NASA-CR-177453; NAS 1.26:177453; TR-1239-1) Avail: NTIS HC A10/MF A01 CSCL 01C

Nap-Of-the-Earth (NOE) flight in a conventional helicopter is extremely taxing for two pilots under visual conditions. Developing a single pilot all-weather NOE capability will require a fully automatic NOE navigation and flight control capability for which innovative guidance and control concepts were examined. Constrained time-optimality provides a validated criterion for automatically controlled NOE maneuvers if the pilot is to have confidence in the automated maneuvering technique. A second focus was to organize the storage and real-time updating of NOE terrain profiles and obstacles in course-oriented coordinates indexed to the mission flight plan. A method is presented for using pre-flight geodetic parameter identification to establish guidance commands for planned flight profiles and alternates. A method is then suggested for interpolating this guidance command information with the aid of forward and side looking sensors within the resolution of the stored data base, enriching the data content with real-time display, guidance, and control purposes. A third focus defined a class of automatic anticipative guidance algorithms and necessary data preview requirements to follow the vertical, lateral, and longitudinal guidance commands dictated by the updated flight profiles and to address the effects of processing delays in digital guidance and control system candidates. The results of this three-fold research effort offer promising alternatives designed to gain pilot acceptance for automatic guidance and control of rotorcraft in NOE operations. Author

N88-12494*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DIGITAL-FLIGHT-CONTROL-SYSTEM SOFTWARE WRITTEN IN AUTOMATED-ENGINEERING-DESIGN LANGUAGE: A USER'S GUIDE OF VERIFICATION AND VALIDATION TOOLS
JIM SAITO Jan. 1987 95 p
(NASA-TM-88313; A-86282; NAS 1.15:88313) Avail: NTIS HC A05/MF A01 CSCL 01C

The user guide of verification and validation (V&V) tools for the Automated Engineering Design (AED) language is specifically written to update the information found in several documents pertaining to the automated verification of flight software tools. The intent is to provide, in one document, all the information necessary to adequately prepare a run to use the AED V&V tools. No attempt is made to discuss the FORTRAN V&V tools since they were not updated and are not currently active. Additionally, the current descriptions of the AED V&V tools are contained and provides information to augment the NASA TM 84276. The AED V&V tools are accessed from the digital flight control systems verification laboratory (DFCSVL) via a PDP-11/60 digital computer. The AED V&V tool interface handlers on the PDP-11/60 generate a Univac run stream which is transmitted to the Univac via a Remote Job Entry (RJE) link. Job execution takes place on the Univac 1100 and the job output is transmitted back to the DFCSVL and stored as a PDP-11/60 printfile. Author

N88-12495*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FLAP-LAG EQUATIONS OF MOTION OF RIGID, ARTICULATED ROTOR BLADES WITH THREE HINGE SEQUENCES
ROBERT T. N. CHEN Nov. 1987 59 p
(NASA-TM-100023; A-87338; NAS 1.15:100023) Avail: NTIS HC A04/MF A01 CSCL 01C

A derivation of coupled flap-lag equations of motion for a rigid articulated rotor with hinge springs and viscous dampers is reported. Three different flapping-lag-pitch hinge sequences are considered and the Lagrange method is used to derive the equations. The effects of the complete six degrees-of-freedom aircraft motions are included and all the inertia dynamic terms are retained; no small-angle assumptions are used in the development. Comparisons of the results with those available in the literature are made. Sources of terms missing in previous analyses, especially those of the inertia dynamics, are identified. Author

N88-12624# Joint Publications Research Service, Arlington, Va.
AIRCRAFT DYNAMIC RESPONSE CALCULATION BASED ON DISCRETE-CONTINUAL MODEL Abstract Only
M. B. VAKHITOV, A. S. SAFONOV, and I. A. KUZNETSOV *In its* USSR Report: Engineering and Equipment p 3 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 16-20
Avail: NTIS HC A06/MF A01

A numerical procedure for the determination of stresses and deformations in cantilevered thin-wall aircraft lifting surfaces under a varying in time load is generalized to take into account the motion of the structure in the aircraft systems as a whole. It was assumed that the aircraft was located in a subsonic compressible flow. Equations of its perturbed motion were derived, only taking into account deformations of its lifting surfaces. External non-stationary aerodynamic loads on deformable lifting surfaces and on a non-deformable aircraft body were determined using the discrete vortex method. The set of equations for deriving parameters of dynamic stress-strain state of aircraft lifting surfaces, of displacements of an aircraft as a whole and of a non-stationary dynamic load consisted of three groups of equations describing the dynamic reaction of the aircraft. Initial conditions for solving these equations are presented. Author

N88-12627# Joint Publications Research Service, Arlington, Va.
LOCAL-OPTIMAL CONTROL IN SYSTEMS WITH DELAY Abstract Only
G. L. DEGTYARYOV and S. A. TERENTYEV *In its* USSR Report: Engineering and Equipment p 7 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 39-42
Avail: NTIS HC A06/MF A01

The problem of determining parameters of the control mechanism in aircraft stabilization systems with the delay that develops in measuring and servosystems is one of the most important problems in developing control systems in modern aircraft. Optimum control was sought as a function of current and previous measurements of the state of the system. Results obtained earlier were expanded. Equations for simulating aircraft movement and for optimum control were proposed. An equation of system motion was derived. Based on conditions of local optimality, a set of equations for determination of controller coefficients was derived.

Solving the set makes it possible to derive the optimal parameters. Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A88-14000#
WIND SHEAR TUNNEL WITH INCLINED WIRE GAUZE
HARUO KIMURA (Kyushu University, Fukuoka, Japan) and HAMID BASSIRI Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 47, June 1987, p. 115-124.

For studying experimentally the aerodynamic characteristics of aircraft in wind shear using a conventional wind tunnel in which the aircraft model is set restrained from linear movement, a method for producing the wind shear condition - the flow field with spatial and temporal gradients - in the tunnel is presented. The spatial wind gradient is obtained by an inclined wire gauze installed upstream in the test section, and the temporal variation, which corresponds to the situation experienced by a moving aircraft, is generated by rotating the gauze or by controlling the tunnel stagnation pressure. This method is applied to a blowdown type wind tunnel and its validity is shown. Author

A88-14272#
INTEGRATION OF MANNED SIMULATION AND FLIGHT TEST IN AN OPERATIONAL TEST AND EVALUATION PROGRAM
MARK J. WILLIAMS and MARK A. HARTFORD (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 8 p.
(AIAA PAPER 87-2924)

A basic outline is presented for integration of a manned simulation test program with a flight test program to accomplish the operational testing and evaluation of a fighter aircraft or a specific fighter weapon subsystem. The intrinsic advantages and disadvantages of operational flight testing and manned simulation are explained. A manned aerial combat simulator is briefly described, along with the benefits of using a simulation to support an operational test. A method of integrating flight test and manned simulation to compensate for their inherent limitations is also presented. This integration provides for a better overall test program than would be possible using either method alone. Issues addressed included the use of a manned simulator for training test participants and as a method of significantly expanding the analytical data base. A sample test matrix and scenario are presented. Analytical issues addressed include possible measures-of-effectiveness to be collected and analyzed during both simulation and flight test. Author

A88-14315
SUPPORT SYSTEMS FOR NEW LIGHTER-THAN-AIR VEHICLES
ROY P. GIBBENS IN: Airship design and operation - Present and future; Proceedings of the International Conference, London, England, Nov. 18, 19, 1986. Volume 2 . London, Royal Aeronautical Society, 1986, p. 18.1 to 18.11.

In order to be cost-effective, ground support equipment such as mooring facilities must be designed along with the airships in question, rather than as an afterthought. Significant savings accrue to the incorporation of in-flight maintenance practices in which servicing equipment and maintenance personnel are carried onboard; their cost is projected to be offset by the achievement of higher levels of reliability. Mooring procedures should be mechanized, and it is recommended that large airships be docked in fully stationary, rather than weathervaning, circumstances. O.C.

A88-16332#
THE EFFECTS OF SUCTION AT SIDEWALL AROUND THE MODEL IN A TRANSONIC AIRFOIL WIND TUNNEL
CHAO GAO and SHIJUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, May 1987, p. A274-A278. In Chinese, with abstract in English. refs

Measured and calculated results on sidewall boundary layers from dry runs in a 300 mm transonic wind tunnel having suction at its solid sidewalls are discussed. The axial Mach number distribution in the dry runs and the effects of sidewall suction on the chordwise and spanwise pressure distributions on a pressure testing model are analyzed. It is found that suction on the sidewall around the model can change the uniformity of the flow field in the dry runs. Suction on the sidewall around the model makes the spanwise pressure distribution uniform but changes the chordwise pressure distribution in the central section. C.D.

A88-16543#
AN ADVANCED SYSTEM FOR PROCESSING DYNAMIC TEST DATA
D. J. STOUDER (Douglas Aircraft Co., Long Beach, CA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 7 p.
(AIAA PAPER 87-2687)

The development, capabilities, and initial use of the Advanced Dynamic Data Processing System (ADDAPS), a system designed for processing large quantities of noise, vibration, and other dynamic test data, are discussed. The discussion covers system design, cost and schedule constraints, requirement specifications, development methodology, and sample outputs. Also discussed are some problems encountered in the initial production use of the system, suggested improvements, and future development plans. V.L.

A88-16676
INTERNATIONAL CONFERENCE ON SIMULATORS, 2ND, UNIVERSITY OF WARWICK, COVENTRY, ENGLAND, SEPT. 7-11, 1986, PROCEEDINGS
Conference organized by IEE. London, Institution of Electrical Engineers (Conference Publication, No. 267), 1986, 239 p. For individual items see A88-16677 to A88-16689.

The conference presents papers on the building of quality software for a command systems simulator, digital propagation simulators, the use of speech technology in air traffic control simulators, flight simulator visual systems, and the computer aided design of surface surveillance radar. Other topics include a simulator for optically sighted, light antiarmor weapons training, cockpit procedure trainers for military aircraft, a real-time power system simulator for hydroturbine plant tests, and the future of flight simulation. Consideration is also given to a low cost flight simulator for twin-engined general aircraft, the FAA advanced simulation plan approval process, and a multiprocessor approach to computer imager generation. K.K.

A88-16680
FLIGHT SIMULATOR VISUAL SYSTEMS
T. W. ROWLEY (General Electric Co., PLC, Hirst Research Centre, Wembley, England) IN: International Conference on Simulators, 2nd, Coventry, England, Sept. 7-11, 1986, Proceedings . London, Institution of Electrical Engineers, 1986, p. 26-30.

Flight simulators are discussed in terms of the following: (1) input controls and operator environments, (2) the vehicle performance simulator, and (3) vehicle performance feedback systems. The scope of visual data is defined with emphasis placed on real world environments and visual data specification (i.e., field of view, edge content, and resolution). Consideration is also given to the operation of a visual system, factors affecting system specification, and future developments. K.K.

A88-16681
A PRACTICAL HELICOPTER CABIN NOISE SIMULATOR
J. A. CHILLERY and J. B. COLLISTER (Royal Aircraft Establishment, Farnborough, England) IN: International Conference on Simulators, 2nd, Coventry, England, Sept. 7-11, 1986, Proceedings . London, Institution of Electrical Engineers, 1986, p. 31-37. refs

A facility has been constructed to simulate the noise fields in helicopter cabins. Helicopter noise reproduction methods are studied with consideration given to signal sources and conditioning, magnetic tape replay, synthetic sources, signal transduction, and output from disk store. The main processor used by the system is a 16-bit minicomputer with normal mass storage and I/O facilities. Output stability was measured as a function of time and variations over an 8-hr day for half power output were found to be less than + or - 1 dB. Applications in Sea King helicopters are described. K.K.

A88-16683
COCKPIT PROCEDURE TRAINERS FOR MILITARY AIRCRAFT
M. COGRAVE and J. W. LYONS (British Aerospace, PLC, London, England) IN: International Conference on Simulators, 2nd, Coventry, England, Sept. 7-11, 1986, Proceedings . London, Institution of Electrical Engineers, 1986, p. 53-58.

The Hawk Mk.60 series cockpit procedure trainer (CPT), which provides levels of simulation adequate to support the training of pilots and ground crew in on-ground cockpit procedures, is described. Certain in-flight procedures such as engine relight, radio and navaid operation, and weapon release are also simulated. CPT standard and enhanced configurations are described; the standard configuration simulates many of the aircraft systems concerned with ground crew and pilot training for engine prestart checks, up to and including the starting and running of the engine. The enhanced configuration makes use of a high level of interactive computer control and monitoring for the instructor. A CPT is also being developed for the Pilatus PC-9 turboprop trainer. K.K.

A88-16686
A LOW COST FLIGHT SIMULATOR FOR TWIN-ENGINED GENERAL AIRCRAFT
D. MCLEAN (Southampton, University, England) and D. A. SETFORD (Scientific Computers, Ltd., Burgess Hill, England) IN: International Conference on Simulators, 2nd, Coventry, England, Sept. 7-11, 1986, Proceedings . London, Institution of Electrical Engineers, 1986, p. 150-154. Research supported by the Loughborough University of Technology, Scientific Computers, Ltd., and SERC.

The need for a low-cost three-axis moving-base flight simulator which would faithfully provide the motion cues appropriate to twin-engined general aviation aircraft is demonstrated. The pitch, roll, and heave axes were chosen, and the aircraft dynamics over the entire flight envelope were simulated using analog circuits. A microprocessor was used to simulate the navigation and communication aids in the selected flight regions. It is noted that safety requirements were built-in so that sudden collapse of the motion base can be prevented. K.K.

A88-16688
THE FAA ADVANCED SIMULATION PLAN APPROVAL PROCESS
J. HUTCHINSON (Singer Link-Miles, Ltd., Lancing, England) IN: International Conference on Simulators, 2nd, Coventry, England, Sept. 7-11, 1986, Proceedings . London, Institution of Electrical Engineers, 1986, p. 176-181.

Some aspects of the certification of civil transport aircraft simulators by the FAA under the Advanced Simulation Plan are discussed. The data requirements, tests, tolerances, and simulation improvements necessary to achieve the three levels of approval given in the FAA Advisory Circular AC120-40 are described. Microprocessor digital control loading technology is currently used to simulate the aircraft control system instead of analog circuitry, and automatic testing has been expanded to check hardware and software. K.K.

N88-11655# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
MBB SIMULATION FACILITIES APPLIED FOR ROTORCRAFT RESEARCH
PETER KRAUSEP, JAMES VANGAASBEEK, and HORST BORCHERT *In* AGARD, Rotorcraft Design for Operations 17 p Jun. 1987
Avail: NTIS HC A14/MF A01

The increasing pilot workload and environmental conditions of modern military helicopters necessitate detailed assessment of cockpit designs with regard to controls and displays. The optimization must be performed at the initialization of the concept to insure a harmonic design with minimum pilot workload. The status of the MBB Munich flight simulation facility is examined closely in light of these challenging requirements. Projections of the future development of the simulation center components are depicted, as well as priorities. Author

N88-11656# Centre d'Essais en Vol, Istres (France).
RESEARCH SIMULATORS FOR HELICOPTERS [SIMULATEURS D'ETUDES POUR HELICOPTERES]
D. JEROME *In* AGARD, Rotorcraft Design for Operations 12 p Jun. 1987 In FRENCH
Avail: NTIS HC A14/MF A01

The helicopter simulation facilities of the Centre d'Essais en Vol at Istres are described. The simulator cabins, imaging techniques, motion simulator methods, and related computer equipment are described. In addition, the Center's research objectives in the areas of vehicle and systems design, crew station organization, and vehicle performance evaluation are outlined. M.G.

N88-11667# Societe de Fabrication d'Instruments de Mesure, Massy (France).
HELICOPTER FIRE CONTROL: ADVANTAGES OF AN AUTOMATIC TARGET TRACKER [CONDUITE DE TIR HELICOPTERE INTERETS D'UNE POURSUITE AUTOMATIQUE DE CIBLE]
B. CERUTTI *In* AGARD, Rotorcraft Design for Operations 5 p Jun. 1987 In FRENCH
Avail: NTIS HC A14/MF A01

Several advantages of target tracking as applied to helicopter fire control are discussed. The principle elements involved in fire control (sighting, armaments and computers) and their respective roles in target acquisition are briefly described. The benefits of automatic target tracking with image processing are examined in terms of operator workload, improvement in tracking rate and noise, and improvement in target kinetic information (precision, noise) for fire control. Finally, the various criteria for control design are presented. M.G.

N88-11681# European Space Agency, Paris (France).
THE 0.6M X 0.6M TRISONIC TEST SECTION (TMK) OF DFVLR IN COLOGNE-PORZ, FEDERAL REPUBLIC OF GERMANY (STATUS 1986)
HELMUT ESCH Jun. 1987 89 p Transl. into ENGLISH of Die 0.6-m x 0.6-m-Trisonische Messtreccke (TMK) der DFVLR in Koeln-Porz (Stand 1986) (Cologne, Fed. Republic of Germany, DFVLR), Mar. 1986 Original language document was announced as N87-26053
(ESA-TT-1052; DFVLR-MITT-86-21; ETN-87-90874) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, Cologne, Fed. Republic of Germany DM 46.50

Information for users of a blowdown wind tunnel is provided. It has a Mach number range from 0.5 to 4.5, with Reynolds numbers, based on a reference length of 1m, between 10 million and 90 million. Typical running times are 60 sec. The Mach number range is extended by the neighboring hypersonic wind tunnel H2K, in which the same models can be tested at Mach numbers up to 11. ESA

N88-11682# European Space Agency, Paris (France).
THE VERTICAL TEST SECTION (VMK) OF DFVLR IN COLOGNE-PORZ, FEDERAL REPUBLIC OF GERMANY (STATUS 1986)
KLAUS TRIESCH and ERNST-OTTO KROHN Jun. 1987 101 p Transl. into ENGLISH of Die Vertikale Messtrecke (VMK) der DFVLR in Koeln-Porz (Stand 1986) (Cologne, Fed. Republic of Germany, DFVLR), May 1986 Original language document was announced as N87-26054
(ESA-TT-1053; DFVLR-MITT-86-22; ETN-87-90875) Avail: NTIS HC A06/MF A01; original German version available from DFVLR, Cologne, Fed. Republic of Germany DM 38

Information for users of a vertical test section blowdown wind tunnel with test section diameters from 150 to 340 mm is presented. The axisymmetric free jet has a Mach number range from 0.5 to 0.95 at subsonic speeds, and from 1.57 to 3.23 at supersonic speeds, with Reynolds numbers, based on a reference length of 1 m, between 3 million and 300 million. Typical testing times are between 30 and 60 sec. ESA

N88-11683 British Aerospace Aircraft Group, Preston (England). Military Aircraft Div.
THE ABILITY OF MODIFIED PAVEMENT QUALITY CONCRETE TO RESIST GROUND EROSION CAUSED BY VTOL AIRCRAFT
A. P. WINSTANLEY Apr. 1987 25 p Original contains color illustrations
(BAE-ARG-238; ETN-87-90936) Avail: Issuing Activity

A fiber reinforced pavement quality concrete (FR PQC) was compared with the normal mix (N PQC) for VTOL aircraft use. The FR PQC lasts slightly longer before the onset of erosion. The FR PQC achieves a slightly higher surface temperature before erosion ensues. The area of erosion after a 40 sec run is less for the FR PQC. The exposed stainless steel fiber area revealed under a FR PQC spall is undesirable with respect to personnel and aircraft tires. Although the FR PQC performs slightly better than the N PQC, this cannot be totally conclusive from such a small sample study. It is possible that the slight gain in performance of the FR PQC sample is due to the reduction of aggregate size, rather than the inclusion of fibers. ESA

N88-11684 Iowa State Univ. of Science and Technology, Ames.
THEORETICAL AND EXPERIMENTAL STUDY OF FLOW-CONTROL DEVICES FOR INLETS OF INDRAFT WIND TUNNELS Ph.D. Thesis
JAMES CARL ROSS 1987 131 p
Avail: Univ. Microfilms Order No. DA8716812

Low-contraction ratio wind tunnel inlets have been shown to generate nonuniform velocity fields in the location where it is necessary to place anti-turbulence screens. The pressure drop experienced by the flow passing through the screens is proportional to the local dynamic pressure and can, therefore, result in a nonuniform test-section velocity distribution. The interaction of screens and two-dimensional inlet flow was examined both theoretically and experimentally. The results indicate that the addition of more screens does not improve the test-section velocity distribution except for a very limited range of inlet geometries. In addition, the turning of the flow by the screens was found to be the most important factor influencing the inlet flow distribution and that the turning action of the screens must be included in any analysis of this type of flow. The use of a set of tuning vanes (cascade) upstream of the screens was found to be effective in modifying the inlet flow distribution so as to generate a uniform test-section velocity distribution. A successful application of the inlet cascade to the 80- by 120-Foot Wind Tunnel at NASA Ames Research Center is also presented. Dissert. Abstr.

N88-11685*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN AERODYNAMIC PERFORMANCE EVALUATION OF THE NASA/AMES RESEARCH CENTER ADVANCED CONCEPTS FLIGHT SIMULATOR M.S. Thesis
PAUL F. DONOHUE Jun. 1987 113 p Prepared in cooperation with NPS, Monterey, Calif.
(NASA-TM-89659; NAS 1.15:89659; AD-A184700) Avail: NTIS HC A06/MF A01 CSCL 14B

The results of an aerodynamic performance evaluation of the National Aeronautics and Space Administration (NASA)/Ames Research Center Advanced Concepts Flight Simulator (ACFS), conducted in association with the Navy-NASA Joint Institute of Aeronautics, are presented. The ACFS is a full-mission flight simulator which provides an excellent platform for the critical evaluation of emerging flight systems and aircrew performance. The propulsion and flight dynamics models were evaluated using classical flight test techniques. The aerodynamic performance model of the ACFS was found to realistically represent that of current day, medium range transport aircraft. Recommendations are provided to enhance the capabilities of the ACFS to a level forecast for 1995 transport aircraft. The graphical and tabular results of this study will establish a performance section of the ACFS Operation's Manual. GRA

N88-12496*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANALYSIS OF 7- X 10-FOOT HIGH SPEED WIND TUNNEL SHAFT LOADS IN SUPPORT OF FAN BLADE FAILURE INVESTIGATION
RICHARD W. FAISON Nov. 1987 49 p
(NASA-TM-100504; NAS 1.15:100504) Avail: NTIS HC A03/MF A01 CSCL 14B

This is a report of the investigation of the High-Speed 7- X 10-Foot Wind Tunnel at NASA Langley Research Center, which experienced a catastrophic failure of all 18 Sitka spruce fan blades during operation at 0.8 Mach number on 2 July 1985. The High-Speed Tunnel, a closed-circuit/single-return atmospheric wind tunnel, had been operated since 1945 to support a wide range of subsonic aerodynamic tests and studies. The failed blade set had been in use since 1975. In addition to blade loss, the most significant damage was a bent main drive shaft for a total estimated damage loss of 1.7 million dollars. An analysis of the natural frequency characteristics as well as loads, reactions, stresses, and deflections of the fan drive system resulting from steady-state and dynamic loads due to unbalance was performed. Transient load cases were simulated by step input and ramp input loading functions intended to simulate the loss of one to nine blades (maximum unbalance forces). Author

N88-12499# Naval Postgraduate School, Monterey, Calif.
AN INEXPENSIVE REAL-TIME INTERACTIVE THREE-DIMENSIONAL FLIGHT SIMULATION SYSTEM Summary Report, 1 Aug. 1986 - 31 Jul. 1987
MICHAEL J. ZYDA, ROBERT B. MCGHEE, DOUGLAS B. SMITH, and DALE G. STREYLE 3 Aug. 1987 232 p
(AD-A184340; NPS52-87-034) Avail: NTIS HC A11/MF A01 CSCL 05I

A prototype flight simulator for the Fiber-Optically Guided Missile (FOG-M) is presented. This prototype demonstrates the practicability and feasibility of using low-cost graphics hardware to produce acceptable simulation of flight over terrain generated from Defense Mapping Agency (DMA) digital elevation data. The flight simulator displays a dynamic, three-dimensional, out-the-window view of the terrain in real-time while responding to operator control inputs. The total system cost (software and hardware) of the simulator is an order of magnitude less than most flight simulation systems in current use. GRA

N88-12500# Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.
OPEN-GRADED BASES FOR AIRFIELD PAVEMENTS Final Report
WALTER R. BARKER Jul. 1987 76 p
(AD-A184461; WES/MP/GL-87-16) Avail: NTIS HC A05/MF A01 CSCL 13B

Water has long been recognized as a major contributor to pavement failures. To lessen the potential for damage due to water, the US Army Corps of Engineers established drainage criteria for bases and subbases in airfield pavements. Since the establishment of the drainage criteria, the use of dense-graded aggregate has become the most used material type for airfield pavement bases. Laboratory studies conducted in the late 1960's indicated that the dense-graded bases were almost impermeable and would not meet the drainage criteria. Bases constructed from a uniform size aggregate (an open-graded base) would provide the required permeability but do not have the stability of a denser graded base. A literature review and field survey on the use of open-graded bases and the results of a pilot test section to illustrate the structural capabilities of open-graded bases and follow-up on some ongoing studies are included in this report. GRA

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A88-13390
SPACE SHUTTLE ORBITER EJECTION SEAT SURVEY
TROY N. WHITEHURST, JR. (Boeing Aerospace Co., Houston, TX) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 92-97.

Available systems to enhance crew escape from the Space Shuttle Orbiter vehicle are surveyed. The attributes believed to be significant to the Orbiter escape system studies are compared. Typical Shuttle trajectory profiles are shown along with ascent and descent velocities vs. altitude. C.D.

A88-15951#
AI APPLICATIONS TO THE COMMAND AND CONTROL OF FUTURE AEROSPACEPLANE VEHICLES
R. C. PARKINSON (British Aerospace, PLC, Space and Communications Div., Stevenage, England) IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 6 p. refs
(IAF PAPER 87-223)

Future low-cost aerospace-plane launch vehicles will place a premium on minimizing operations costs. At the same time such vehicles may be required to carry out most flights as unmanned, automatic systems. As a consequence, there will be a high reliance on automatic control systems and data interpretation. The need for successful vehicle recovery even when the launch itself is aborted extends these requirements into the safety-critical area of flight control. AI techniques appear to be the key to achieving cost-effective automatic recoverable launch systems, but the applications will have to be carefully evaluated against the techniques available. Key features required for such systems will be transparency to a human operator remote from the vehicle itself (but having to make rapid and effective decisions throughout the vehicle operational cycle) and educability (to extend the system as operational experience accrues). Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A88-13138
FIBER FORM/PRESSURE MOLDING PROCESSING FOR AIRCRAFT FUSELAGE SUBSTRUCTURE
GARY VAN SCHOONEVELD (XERKON, Inc., Minneapolis, MN) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 . Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 123-133.

As the application of composite materials continues to expand into aircraft primary structures, new manufacturing technologies are required to ensure repeatability and cost effectiveness of the structures. Fuselage frames represent a major challenge due to their complex curvature and variable cross-section. The fiber form/Autocomp pressure molding manufacturing approach has been demonstrated on a number of fuselage frame sections. Savings up to 70 percent have been projected for this manufacturing approach, as compared to conventional hand layup/autoclave processing. The reinforcing fiber is knitted into unidirectional and multiple ply fabrics without bending the reinforcing fiber and assembled via stitching to the final configuration of the molded part. The dry fiber form is impregnated by means of a resin infusion process. Final curing of the frame is achieved with the patented Autocomp pressure moding process. The process utilizes integrally heated, matched surface tooling in conjunction with vacuum and pressure. Precise computer control of the process provides high manufacturing throughput and part-to-part consistency. Author

A88-13148
FIELD REPAIR COMPOUNDS FOR THERMOSET AND THERMOPLASTIC COMPOSITES
EDWIN C. CLARK and KENNETH D. CRESSY (Furane Products Co., Los Angeles, CA) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 . Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 271-278. refs

There is currently a push by the aerospace industry to utilize more thermoset and thermoplastic materials in the construction of aircraft. This has created new demands for repair of these vehicles in the field. Restrictions imposed on repair materials in the field environment were used to evaluate current repair techniques. This evaluation uncovered the need for materials that perform at higher temperatures and have the ability to bond contaminated surfaces. These deficiencies were most pronounced in the repair of composite laminates and adhesive bonded structures. Syntactic materials currently being used to repair damaged honeycomb were found to meet repair requirements. There is also a lack of data on the use of field repair materials on the new generation thermoplastics. It is in the area of high temperature performance, surface insensitivity, and thermoplastic repair that future developmental work must be focused. Author

A88-13168
A COMPUTER AIDED AIRCRAFT STRUCTURAL COMPOSITE REPAIR SYSTEM
FORREST SANDOW (UASF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 . Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 551-557.

PCs can solve many of the design problems that emerge in repair procedures for military aircraft applications of advanced composite materials. Attention is presently given to a CAD system for the analysis of damage, the design of repair measures, and the formulation of repair procedures. Interactive computer programs are under development for the determination of stresses, strains, and strengths around a damage area, using complex potentials, the quadratic failure criterion, and point-stress fracture theory. The moisture content of damaged structures is also noted by these methods. O.C.

A88-13177
COMPOSITE DRIVE SHAFTING APPLICATIONS
BRIAN E. SPENCER (Brunswick Corp., Lincoln, NE) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 . Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 650-661. refs

Advancements in composite design and processing techniques have led to the increased production of composite driveshafts for automobile and helicopter drivetrain applications, as costs have been reduced by more refined methods and impact resistance levels have been increased by the development of superior resins. Attention is presently given to: (1) high torque, thick-wall shafts manufactured by a laminate composite cylinder filament-winding process that yields a mere 1-percent void content, (2) the 'no cut fiber' coupling concept for the transmission of torque to and from composite shafts, and (3) an analytical model that predicts the residual stresses in such filament-wound cylinders. O.C.

A88-13198
DEVELOPMENT OF PARTICULATE REINFORCED HIGH STRENGTH ALUMINIUM ALLOY FOR AEROSPACE APPLICATIONS
C. G. KRISHNADAS NAIR, D. DUTTA (Hindustan Aeronautics, Ltd., Bangalore, India), and M. R. KRISHNADEV (Universite Laval, Quebec, Canada) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 . Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 889-901.

A SiC particulate-reinforced, high strength Zr-refined Al-Zn-Mg-Cu alloy has been produced by PM. Powder prepared by gas atomization is mixed with SiC particulates in vacuum, followed by hot pressing and extrusion. Microstructure and properties of the composite are discussed. The resulting alloy is forgeable and heat-treatable to develop high strength. The alloy is economical to produce and is considerably cheaper than the Al-Li alloys. Author

A88-13220
AUTOMATED FABRICATION OF GRAPHITE-EPOXY COMPOSITES
WALTER J. KAU, MICHAEL W. MATSON, and JONATHAN P. RUSSELL (Boeing Military Airplane Co., Seattle, WA) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 . Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 1152-1155.

A proprietary system for the automated fabrication of graphite-epoxy composite primary aircraft structures is presented which encompasses direct numerical control of prepreg layup procedures and quality control process-monitoring. Experience with the system thus far has indicated that automation is best applied to large structures, difficult layups, and parts made from standard cross-sections. The elements of the automated system encompass flat and contour shape laminators, a channel stiffener manufacturing system, a pultruder, a computer-controlled autoclave, and a five-axis router. O.C.

A88-13225
AN OVERVIEW OF FIRE BLOCKING FABRICS
NEIL SAVILLE (Universal Carbon Fibres, Ltd., Gomersal Mills, England) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 . Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 1347-1359.

The roles played by fibers, fabric and foam properties, seam problems, and passenger comfort considerations in the manufacture of fire-blocking airliner seats are discussed in view of FAR 25 853 (C) appendix F. Attention is given to test method repeatability, and the ability of Panox/Kevlar/aramid fiber fabrics to interact during burning in such a way as to maximize blockage against fire. Typical aramid fibers are Nomex and Conex; their contraction by 30 percent during burning can be used as a way of closing fiber pores to resist burn-through. O.C.

A88-13235
COMPOSITE STRUCTURES IN HOMEBUILT SPORT AIRCRAFT
ANDREW C. MARSHALL (Orcon Corp., Union City, CA) IN: Advanced materials technology '87; Proceedings of the Thirty-second International SAMPE Symposium and Exhibition, Anaheim, CA, Apr. 6-9, 1987 . Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 1510-1518.

The use of composite materials in aircraft built in home workshops has resulted in a major improvement in appearance, styling, and performance. This paper examines some of the reasons behind this shift in the small-aircraft industry. A brief summary of construction materials, performance, and appearance of a few of these modern homebuilt aircraft are presented. Author

A88-13407
LASER FIBER OPTIC INITIATION SYSTEM
BEN E. PAUL, JOHN A. COBBETT, and JOUNG R. COOK (Scot, Inc., Downers Grove, IL) IN: SAFE Association, Annual Symposium, 24th, San Antonio, TX, Dec. 11-13, 1986, Proceedings . Newhall, CA, SAFE Association, 1987, p. 244-246.
(Contract N00174-83-C-0227)

A program has been undertaken to develop pyrolaser technology for the design of laser/fiber optic initiation systems. The hardware fabrication and demonstration phase will contain 1 and 2 inch diameter mechanically actuated pyrolaser initiators, with nominally 4 and 20 J output, respectively. Designs for all the auxiliary escape system components for use with pyrolaser/fiber optics have also been developed, including one-way transfers, crossovers, and mode selectors. The reliability testing completed for the pyrolaser pumping source (the zirconium wool bulbs) is described. K.K.

A88-15106
STRESS CORROSION CRACKING OF 4340 STEEL IN AIRCRAFT IGNITION STARTER RESIDUES
KEVIN J. KENNELLEY and RAYMOND D. DANIELS (Oklahoma, University, Norman) IN: Corrosion cracking . Metals Park, OH, ASM International, 1986, p. 199-204. refs
(Contract F34601-83-C-3448)

Military aircraft use a cartridge ignition system for emergency engine starts. Premature failures of steel (AISI 4340) breech chambers in which the solid propellant cartridges are burned is a serious concern. Analysis of a number of breech chamber failures identified corrosion as one problem with an indication that stress corrosion cracking may also be occurring. A study was made for stress corrosion cracking susceptibility of 4340 steel in a paste made of the residues collected from used breech chambers. The constant extension rate test (CERT) technique was employed and

SCC susceptibility was demonstrated. The residues, which contain both combustion products from the cartridges and corrosion products from the chamber, were analyzed using elemental analysis and X-ray diffraction techniques. Electrochemical polarization techniques were also utilized to estimate corrosion rates. Author

A88-15120*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROGRESS TOWARD LIFE MODELING OF THERMAL BARRIER COATINGS FOR AIRCRAFT GAS TURBINE ENGINES
R. A. MILLER (*NASA, Lewis Research Center, Cleveland, OH*) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 109, Oct. 1987, p. 448-451. refs
(ASME PAPER 87-ICE-18)

Progress toward developing life models for simulating the behavior of thermal barrier coatings in aircraffft gas turbine engines is discussed. A preliminary laboratory model is described as are current efforts to develop engine-capable models. Current understanding of failure mechanisms is also summarized. Author

A88-16007#
THE HISTORY OF FIBRE-REINFORCED PLASTICS AT FOKKER - ACHIEVEMENTS AND LESSONS LEARNED
M. P. NIEUWENHUIZEN IAF, International Astronautical Congress, 38th, Brighton, England, Oct. 10-17, 1987. 28 p.
(IAF PAPER 87-306)

The problems and considerations involved in the applications of composites with carbon, glass, and aramid fiber reinforcements in aerospace structures are examined in the light of aeronautical experience at Fokker. Some major Fokker products made of composites are characterized, and difficulties encountered in their development are discussed. Attention is given to material research, inspection methods, construction development, stressing methods, and damage tolerance characteristics. The manufacturing aspects are discussed with emphasis on cost effectiveness and quality control. V.L.

A88-16331#
THE EFFECTS OF PRESTRESS ON LOW CYCLE FATIGUE AND FATIGUE CRACK GROWTH BEHAVIOURS FOR ALLOY GH33A
SHAOLUN LIU, JIZHOU XIE (Institute of Aeronautical Materials, Beijing, People's Republic of China), and XIANGSON LIU (Institute of Aeronautical Engines, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, May 1987, p. A267-A273. In Chinese, with abstract in English. refs

The effects of tensile prestress on low-cycle fatigue and fatigue crack growth rates for Ni-base alloy GH33A used for turbine engine disks were investigated at 360 C. The experimental results show that the low-cycle fatigue crack initiation life Ni will be increased by prestressing treatment within the range of low-cycle fatigue life 10,000-50,000, but the effect of prestress on fatigue crack propagation life Np is not obvious. Author

A88-16742
FIRE AND CELLULAR POLYMERS
J. M. BUIST, ED. (*Abelard Management Consultancy, Cheshire,* England), S. J. GRAYSON, ED. (Queen Mary College, London, England), and W. D. WOOLLEY, ED. (Fire Research Station, Borehamwood, England) London and New York, Elsevier Applied Science, 1986, 330 p. For individual items see A88-16743 to A88-16745.

Papers are presented on cellular polymers, the fundamentals of fire behavior of cellular polymers, the performance of foam under fire conditions, and the fire performance of building elements incorporating cellular polymers. Also considered are the fire behavior of rigid foam insulation boards, fire and foams in aircraft applications, the fire performance and characteristics of British Rail flexible polyurethane foam seating, and fire hazards associated with the use of cellular polymers on HM ships. Other topics include PVC foams, the fire properties of isocyanate based rigid foams, the performance of flame retardants in rigid polyurethane foam formulations, and flexible polyurethane foam technology. R.R.

A88-16745
FIRE AND FOAMS IN TRANSPORT APPLICATIONS - AIRCRAFT
L. VIRR (Civil Aviation Authority, Redhill, England) IN: Fire and cellular polymers . London and New York, Elsevier Applied Science, 1986, p. 165-173.

This paper deals with the application of foams within aircraft cabins, the associated resistance to fire standards contained in air-worthiness requirements and their relationship to the various potential fire risks. The results of international research into the improvement of these fire standards, with particular emphasis on the use of polyurethane foams within aircraft seat cushions are discussed. The results of CAA sponsored research undertaken by the Fire Research Station using different material combinations and different ignition sources are illustrated. Author

N88-11876# Joint Publications Research Service, Arlington, Va.
STATUS OF TITANIUM ALLOYS R AND D DESCRIBED
FANCHANG CENG *In its* China report: Science and Technology p 39-45 9 Apr. 1987 Transl. into ENGLISH from Guoji Hangkong (Beijing, Peoples Republic of China), no. 10, 5 Oct. 1986 p 8-11
Avail: NTIS HC A06/MF A01

After a brief chronological description of titanium alloys in the aviation industry, highlights are given on the achievements in manufacturing of large forgings, in particular, high speed hammer forging, high temperature forging, and isothermal die forging. A prospect of titanium alloy development is outlined. Author

N88-12548# Boeing Military Airplane Development, Seattle, Wash.
FAILURE ANALYSIS OF COMPOSITE STRUCTURE MATERIALS Final Report, 1 Oct. 1985 - 31 Aug. 1986
BRIAN SMITH and RAY GROVE 27 May 1987 191 p
(Contract F33615-84-C-5010)
(AD-A184468; AFWAL-TR-87-4001) Avail: NTIS HC A09/MF A01 CSCL 11D

The objectives of the Failure Analysis for Composite Structural Materials program are to develop analytical and diagnostic techniques that can be used for determining the causes of failure in composite materials and to incorporate these results into a compendium of procedures that may be used as a reference manual when conducting a postfailure analysis of a composite structure, given the failed part as the starting point of the investigation. Such techniques include flowcharts describing the logical arrangement of investigative operations along with diagnostic procedures that reveal the cause and mechanism of failure. To achieve these objectives, this program was divided into five tasks: (1) task 1-literature search and diagnostic technique selection, (2) task 2-specimen production and test, (3) task 3-diagnostic technique evaluations, (4) task 4-creation of a failure analysis compendium, and (5) task 5-evaluation and demonstration of techniques. This final report summarizes the progress and findings of activities carried out for tasks 1 through 5 that identified, organized, and examined a variety of postfailure analysis methods for composite materials. Because such failures may arise from a wide variety of causes, analysis techniques examined included four basic disciplines: nondestructive evaluation (NDE), stress analysis, fractography, and materials characterization. GRA

N88-12550# Sandia National Labs., Albuquerque, N. Mex.
PARACHUTE MATERIALS
C. W. PETERSON and D. W. JOHNSON Jun. 1987 72 p
Presented at the Parachute Systems Technology: Fundamentals, Concepts, and Applications, Munich, Fed. Republic of Germany, 22 Jun. 1987
(Contract DE-AC04-76DP-00789)
(DE87-014845; SAND-87-1396C; CONF-8706165-4) Avail: NTIS HC A04/MF A01

The purpose of this paper is to present guidelines for the use of Kevlar and nylon materials in modern parachute systems. Nylon has been used in parachutes for many years, so this discussion will place emphasis upon Kevlar material properties and their application to parachute design and construction. Kevlar-29 is an

aramid fiber manufactured by DuPont and is being used on parachute systems requiring high strength-to-weight ratios or sustained strength at high temperatures. Tests of parachutes using Kevlar webbing, braided cords, ribbons, and thread have demonstrated that these Kevlar materials can be used successfully in ribbon parachutes with no detrimental effects on performance. A few changes must be made in the design of a ribbon parachute to accommodate Kevlar's high modulus. Examples of parachutes that use Kevlar suspension lines, radials, ribbons, reefing lines, bridles, and skirt bands are presented to show that they are much lighter and more resistant to aerodynamic heating than all-nylon parachutes. Nylon continues to be an important material for high-performance parachute systems, however. New nylon weaves have resulted in lighter weight, stronger ribbon materials with excellent sewability characteristics. DOE

N88-12552*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPOSITE MECHANICS FOR ENGINE STRUCTURES
CHRISTOS C. CHAMIS 1987 35 p Presented at the 32nd International Gas Turbine Conference and Exhibition, Anaheim, Calif., 31- May - 4 Jun. 1987; sponsored by ASME
(NASA-TM-100176; E-3750; NAS 1.15:100176) Avail: NTIS HC A03/MF A01 CSCL 11D

Recent research activities and accomplishments at Lewis Research Center on composite mechanics for engine structures are summarized. The activities focused mainly on developing procedures for the computational simulation of composite intrinsic and structural behavior. The computational simulation encompasses all aspects of composite mechanics, advanced three-dimensional finite-element methods, damage tolerance, composite structural and dynamic response, and structural tailoring and optimization. Author

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A88-13268
POTENTIAL HYDRODYNAMIC EFFECTS ON STRUCTURES BY THE BOUNDARY ELEMENT METHOD
D. OUAZAR and N. BENMANSOUR (Mohammadia School of Engineers, Rabat, Morocco) IN: Betech 86; Proceedings of the Second Boundary Element Technology Conference, Cambridge, MA, June 17-19, 1986 . Southampton, England and Billerica, MA, Computational Mechanics Publications, 1986, p. 331-345. refs

Problems based on a potential or streamfunction formulation of the BEM for the studying of hydrodynamic forces are addressed, with particular attention given to fluid applications of the constant conventional BEM (CBEM) and the regular BEM (RBEM). Comparison of the two methods for three numerical examples (the flow past a circular obstacle in an infinite medium, the flow past a circular obstacle in a channel, and the flow past a symmetric NACA 0018 airfoil) demonstrates the superiority of the RBEM over the CBEM in both accuracy and computational cost. It is noted that the optimal location of the singular points outside the domain remains unsolved on a rational basis. R.R.

A88-13281
SHAPE OPTIMIZATION UTILIZING A BOUNDARY ELEMENT FORMULATION
J. H. KANE (Computer Aided Engineering Associates, Inc., Woodbury, CT) IN: Betech 86; Proceedings of the Second Boundary Element Technology Conference, Cambridge, MA, June 17-19, 1986 . Southampton, England and Billerica, MA, Computational Mechanics Publications, 1986, p. 781-803. refs

An analytical formulation of numerical techniques for shape optimization is discussed, demonstrating the competitiveness of the boundary element formulation with respect to the finite element formulation for shape optimization of elastic solid objects. Computer programming aspects including geometry, analysis, sensitivity analysis, numerical optimization, and computer graphics are described. Implicit differentiation of the discretized boundary integral equations is shown to be an accurate and computationally efficient method for design sensitivity analysis. Quadratic, nonconforming, isoparametric boundary elements are employed, yielding multizone analysis capability. R.R.

A88-13342
STABILIZATION OF PRECESSION-FREE ROTORS SUPPORTED BY MAGNETS
SHOSUKE SASAKI (Osaka University, Toyonaka, Japan) Journal of Applied Physics (ISSN 0021-8979), vol. 62, Oct. 1, 1987, p. 2610-2615. refs

Two types of precession-free magnetic-suspension rotors are proposed, and the equations of motion for these rotors are presented and solved. The equipment of the type I rotor consists of an induction motor, two sets of suspension magnets, a servomechanism to keep the vertical position of the rotor, and a magnetic precession damper. In the type II rotor, a mechanical device is employed instead of the servomechanism and the magnetic precession damper of the type I rotor. The solutions for the rotating motion of both rotors show that these rotors have very stable rotation. In a preliminary experiment with the type II rotor, a stable rotation of 120,000 rpm was achieved. A higher-speed rotation can be reached easily in the type I equipment because the rotor can be made so as to have a very high resonance frequency for its bending vibration. I.S.

A88-13426
FLOWS WITH SEPARATION; DGLR SPECIALISTS' SYMPOSIUM, 5TH, MUNICH, FEDERAL REPUBLIC OF GERMANY, OCT. 9, 10, 1986, REPORTS [STROEMUNGEN MIT ABLOESUNG; DGLR-FACH-SYMPOSIUM, 5TH, MUNICH, FEDERAL REPUBLIC OF GERMANY, OCT. 9, 10, 1986, BERICHTE]
Symposium sponsored by DGLR and BMFT;. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, 443 p. In German and English. For individual items see A88-13427 to A88-13442.
(Contract BMFT-LFF-860279)
(DGLR-BERICHT 86-03)

Various papers on flow with separation are presented. Individual topics addressed include: inverse boundary layer method for separated flows; experimental investigations of the structure and 'bursting' of eddies at a slender aircraft wing; experience using the NASA-Langley technique of a free-flying model in a wind tunnel; experimental investigations of shock-boundary layer interference with passive influence, of double delta wings with asymmetric flows, and of duck configurations; force and pressure distribution measurements on a supported 65 delta wing for subsonic and transonic Mach numbers. Also discussed are: flow studies on a 65 delta wing with MA = 0.85; calculations of nonlinear aerodynamic characteristics of interfering airfoils using an eddy cascade method with subsonic flow; stability analysis as an aid to developing laminar profiles; instability of local separation regions against longitudinal eddies; calculation of cascade flows with local separation regions; pressure-wave boundary layer interaction; influencing wake flows. C.D.

A88-13427#
EDDY GENERATION IN HEAT CONDUCTORS [WIRBELGENERATOREN IN WAERMEUBERTRAGERN]
U. BROCKMEIER, N. K. MITRA, and M. FIEBIG (Bochum, Ruhr-Universitaet, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 3-33. In German. refs

The flow structure, pressure, and temperature distribution of turbulators on the segment surfaces of segmental heat exchangers are investigated. The flow is solved numerically using the fully three-dimensional, incompressible Navier-Stokes equations. The numeric is based on a semiimplicit procedure with multigrid technique. Calculations are performed for a test configuration consisting of two segments and a delta wing as turbulator. The delta wing front edge eddies are studied, including their effect on heat conduction. C.D.

A88-13440#
PRESSURE WAVE-BOUNDARY LAYER INTERACTION [DRUCKWELLEN-GRENZSCHICHT WECHSELWIRKUNG]
H. REISTER and H. OERTEL (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: Flows with separation; DGLR Specialists' Symposium, 5th, Munich, Federal Republic of Germany, Oct. 9, 10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 409-414. In German. refs

The interaction with laminar and turbulent plate boundary layers of pressure waves arising toward the rear edges in flow around flat plates, airfoil wing profiles, and turbine cascade profile layers is numerically simulated. A Runge-Kutta finite volume method is used to solve the compressible Navier-Stokes equations. The results show that the waves build up to a sawtooth density shock and are simultaneously damped. In the laminar boundary layer, unsteady regions of back flow build up from a critical pressure amplitude; in the turbulent case, no unsteady separation occurs for realistic amplitudes. C.D.

A88-13737
DEVELOPMENT OF FLUID MECHANICS AT THE SIBERIAN BRANCH OF THE ACADEMY OF SCIENCES OF THE USSR [RAZVITIE GIDROMEKHANIKI V SIBIRSKOM OTDELENII AN SSSR]
B. A. LUGOVTSOV and L. V. OVSIANNIKOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1987, p. 3-22. In Russian. refs

Results of research in the field of fluid mechanics conducted at the Siberian Branch of the Academy of Sciences of the USSR since its establishment are reviewed. In particular, attention is given to developments in the group analysis of differential fluid mechanics equations, free-boundary motions, approximations in wave theory, linear waves, free-boundary flows of viscous fluids, and inertial motion of a finite mass of fluid. The discussion also covers results obtained in shock wave interactions, filtering flows, stationary potential vortex flows, vortex rings, hydrodynamic stability, turbulence, and aeroelasticity. V.L.

A88-13940
FREE VIBRATION OF CONICAL SHELL PANELS
R. S. SRINIVASAN and P. A. KRISHNAN (Indian Institute of Technology, Madras, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 117, Aug. 22, 1987, p. 153-160. refs

The free vibration of an edge-clamped isotropic elastic conical shell panel is investigated analytically. An integral-equation approach is employed, and the convergence of numerical calculations based on a 7 x 7 mesh is demonstrated. Results for several typical geometries are presented in tables and graphs and briefly characterized. T.K.

A88-13965
FREE VIBRATION CHARACTERISTICS OF DAMPED SANDWICH PANEL STIFFENED WITH DAMPED STRINGERS
B. V. R. GUPTA (Andhra University, Waltair, India), S. NARAYANAN, and N. GANESAN (Indian Institute of Technology, Madras, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 117, Sept. 8, 1987, p. 393-398. refs

The free vibration of a damped sandwich panel reinforced with damped top-hat stringers is investigated analytically using the wave approach of Mead (1976). Numerical results are presented in extensive tables and graphs and compared with published data on bare panels. Constrained damping on the flanges is shown to give higher overall damping than unconstrained damping, with maximum effect in the stringer bending mode and minimum effect in the stringer torsion mode. The improvement in overall damping due to damped stringers is found to be marginal. T.K.

A88-14019#
AN INVESTIGATION OF THE STRUCTURE OF A GROUND-TRAILING VORTEX
GUOCAI TANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Sept. 1987, p. 271-277. In Chinese, with abstract in English.

A detailed experimental investigation is presented on the structure of the trailing vortex from a ground vortex. The experiment was conducted in the MIT W. B. wind tunnel. Measurements were made with a five-hole probe to obtain velocity vector distributions along two rectangular contours, giving circulations and the location of the vortex center. The difference between the two circulations and the feature of the flow field along the engine outer surface suggests a sheet-like structure of the trailing vortex with most of the vorticity concentrated in the vortex core. The results thus not only bear out quantitatively the existence of the ground-trailing vortex but also reveal for the first time the sheet-like structure of the trailing vortex and provide a flow model for this new flow phenomenon. Author

A88-14141
FORUM ON UNSTEADY FLOW SEPARATION, CINCINNATI, OH, JUNE 14-17, 1987, PROCEEDINGS
KIRTI N. GHIA, ED. (Cincinnati, University, OH) Forum sponsored by ASME. New York, American Society of Mechanical Engineers, 1987, 255 p. For individual items see A88-14142 to A88-14167.

Papers are presented on nonlinear neutral modes in the Blasius boundary layer, the response of a delta wing in steady and unsteady flow, a numerical simulation of vortex breakdown, and strong blade-vortex interactions, including collision. Also considered are break-up in unsteady separation, unsteady separation at low Reynolds numbers, subharmonic instability in boundary layers, and the flow structure in the wake of an oscillating cylinder. Other topics include the simulation of unsteady flow separation, features of transitional separation bubbles in an oscillating freestream, the effect of pitch location on dynamic stall, and flow separation in dump combustors. R.R.

A88-14149#
BREAK-UP IN UNSTEADY SEPARATION
F. T. SMITH (University College, London, England) IN: Forum on Unsteady Flow Separation, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 55-64. refs

The unsteady break-up of otherwise steady or unsteady separating flows, and unsteady boundary layers in general, is addressed theoretically. The aspects involved are intimately bound up with transition to turbulence in practice. The first aspect is the prediction of the critical position for enhanced instability to occur in separating flow. The second, as a consequence, is the break-up of a separated eddy due to nonlinear unsteady effects, on the small or the large scale. The third aspect is the nonlinear receptivity of attached and separating flows to freestream disturbances. Fourth, and again in consequence, the complete break-up of an unsteady interacting boundary layer is described. Two-versus three-dimensional effects, comparisons with some experimental

and computational results, and applications in a number of external and internal flows are also discussed. Author

A88-14175*# Princeton Univ., N. J.
THE CALIBRATION AND OPERATION OF A CONSTANT-TEMPERATURE CROSSED-WIRE PROBE IN SUPERSONIC FLOW
E. M. FERNANDO, J. F. DONOVAN, and A. J. SMITS (Princeton University, NJ) IN: Symposium on Thermal Anemometry, Cincinnati, OH, June 14-17, 1987, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 43-49. refs
(Contract NAG1-545)

The calibration and operation of a constant-temperature crossed-wire probe in supersonic flow is considered. Crossed-wire probes offer considerable advantages over single, inclined wires: the kinematic shear stress can be derived from a single point measurement; the rms quantities can be derived from the same measurement, and the instantaneous quantities can be obtained as a continuous function of time. However, using a crossed-wire probe in supersonic flow is subject to the following practical difficulties: the problem of flow interference, where the shock waves from one wire and its supports interfere with the flow over the other wire; the necessity for high frequency response to resolve the spectral content, and the sensitivity of the results to small changes in the calibration constants. In the present contribution, each of these problems is addressed. Practical solutions are suggested, and some encouraging results are presented. Author

A88-14248#
A STUDY OF A MULTI-LAYERED THIN FILM HEAT TRANSFER GAUGE AND A NEW METHOD OF MEASURING HEAT TRANSFER RATE WITH IT
MASANORI HAYASHI, AKIRA SAKURAI, and SHIGERU ASO (Kyushu University, Fukuoka, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 30, Aug. 1987, p. 91-101. Translation. Previously cited in issue 10, p. 1378, Accession no. A86-25228. refs

A new method of measuring heat transfer rate with high spatial resolution and fast response is developed to be used in wind tunnels with long flow duration. For the development of the new method a multilayered thin-film heat transfer gage is proposed. The principle of the sensor is based on measuring the temperature gradient across a thin heat-resistant layer of SiO with two thin film resistance thermometers on its upper and lower surfaces. These thin films and the heat-resistant layer are deposited by the vacuum evaporation technique. The design considerations, the accuracy of the sensor, the frequency response, and the calibration technique are discussed. The sensor is applied to the measurement of the heat transfer rate in a turbulent boundary layer on a flat plate at Mach number 4, Tw/TO = 0.64, and Re = 1.4 x 10 to the 7th, and shows high sensitivity and fast response. It also shows excellent durability. Author

A88-14280#
DO WE REALLY UNDERSTAND MAINTENANCE?
THOMAS D. MATTESON AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 6 p. refs
(AIAA PAPER 87-2943)

The design of applicable and effective maintenance programs requires a body of knowledge that is distinct from that entailed in ensuring aircraft maintainability. The results of actuarial analyses for a wide range of items have disproved several historically dominant beliefs concerning the effects of age on complex hardware reliability. Maintenance requirements should focus on maintaining function, rather than all the physical characteristics of a design. These reliability-centered maintenance practices are presently discussed. O.C.

A88-14536
OBSERVERS FOR FAILURE DETECTION OF ACTUATION SYSTEMS
HAGOP V. PANOSSIAN (HR Textron, Inc., Valencia, CA) IN: ISTFA 1986 - International Symposium for Testing and Failure Analysis; Proceedings of the Symposium, Los Angeles, CA, Oct. 20-24, 1986 . Metals Park, OH, ASM International, 1986, p. 275-278. refs

The states and parameters of an actuation system are estimated using realistic measurements. Linear observers are utilized on a linear model of a hydraulic actuation system generated thorugh linearization under appropriate conditions. Both deterministic and stochastic observers are applied, the latter under realistic state and measurement noise. A procedure is outlined whereby these estimates can be used for detecting and isolating anomalous behavior that could lead to total failures. Results from simulations are presented in plots indicating values of states and parameters versus their respective estimates. The implications of the behaviors of the states and parameters are related to failure detection and isolation. Author

A88-14925
PROBABILISTIC DURABILITY ANALYSIS METHODS FOR METALLIC AIRFRAMES
J. N. YANG (George Washington University, Washington, DC), S. D. MANNING (General Dynamics Corp., Fort Worth, TX), J. L. RUDD, and M. E. ARTLEY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) Probabilistic Engineering Mechanics (ISSN 0266-8920), vol. 2, March 1987, p. 9-15. refs

Probabilistic-based deterministic and stochastic crack growth approaches are compared and evaluated for durability analysis applications dealing with fatigue cracking in metallic fastener holds. Crack exceedance predictions for the deterministic crack growth approach correlated well with experimental results. Correlations for the stochastic crack growth approach were more conservative and less accurate than those for the deterministic crack growth approach. Author

A88-15113
ANALYZING FAILURES: THE PROBLEMS AND THE SOLUTIONS
V. S. GOEL, ED. Metals Park, OH, ASM International, 1986, 362 p. For individual items see A88-15114 to A88-15116.

Papers are presented on a failure analysis of a large centrifugal blower, field fractures in heavy equipment, a failure analysis of a liquid propane gas cylinder, an analysis of helicopter blade fatigue fracture by digital fractographic imaging analysis, and the influence of failure analyses on materials technology and design. Also considered are an analysis of aircraft component failures, the growth of short cracks in IN718, the improper fabrication of rotating blades (resulting in premature failure), and low cycle thermal fatigue and fracture of reinforced piping. Other topics include a nonlinear finite element analysis of stress concentration at high temperature, the inelastic analysis of a hot spot on a heavy vessel wall, the accuracy and precision of mechanical test data generated using computerized testing systems, and maintenance related failures. R.R.

A88-15114
FAILURE ANALYSES OF STEEL BREECH CHAMBERS USED WITH AIRCRAFT CARTRIDGE IGNITION STARTERS
PHILIP C. PERKINS, RAYMOND D. DANIELS (Oklahoma, University, Norman), and A. BRUCE GILLIES (USAF, Oklahoma City Air Logistics Center, Tinker AFB, OK) IN: Analyzing failures: The problems and the solutions . Metals Park, OH, ASM International, 1986, p. 143-149.
(Contract F34601-85-C-0791)

Cartridge-pneumatic starter systems are used in military aircraft. In the cartridge mode used for alert starts, the starter turbine is driven by hot gases produced through the controlled burning of a solid propellant cartridge within a closed chamber. Premature failures of steel breech chambers have been prevalent enough to cause serious concern. Factors identified as significant in the

failures are the pressure developed in the chamber and internal corrosion of the chamber in an environment that can produce stress corrosion cracking. The interior configuration of the chamber and the stress distribution also have a bearing upon the failure modes. Several failures are reviewed to illustrate the problems. Author

A88-15118
FATIGUE LIFE: ANALYSIS AND PREDICTION
V. S. GOEL, ED. Metals Park, OH, American Society for Metals, 1986, 427 p. No individual items are abstracted in this volume.

Theoretical and practical aspects of fatigue life prediction are examined in reviews and reports. Topics discussed include fatigue resistance and safety of butt welds, H2 and humidity effects on the fatigue behavior of a 70-30 Cu-Ni alloy, fatigue cracking of Ti tubes in an industrial heat exchanger, and subcritical growth of small fatigue cracks. Consideration is given to failure analysis of miniature bearings, computer-controlled fatigue crack growth rate testing using the J integral, modeling strain-ratio effects on low-cycle fatigue life, and ultrasonic characterization of crack closure. T.K.

A88-15145
THREE-DIMENSIONAL PHOTOELASTIC ANALYSIS OF AEROENGINE ROTARY PARTS
K. UCHINO, T. KAMIYAMA, T. INAMURA, K. SIMOKOHGE, H. AONO (Ishikawajima-Harima Heavy Industries Co., Ltd., Ohtemachi, Japan) et al. IN: Photoelasticity; Proceedings of the International Symposium, Tokyo, Japan, May 13-15, 1986 . Tokyo and New York, Springer-Verlag, 1986, p. 209-214.

The role of three-dimensional photoelasticity in the design of the flow path of aircraft gas turbine engines is examined with reference to specific examples. In particular, two examples (a double stress concentration problem in blade-disk attachment and the problem of an annulus filler with complicated three-dimensional features) are shown to demonstrate the importance of three-dimensional elasticity in predicting stress distributions in rotary parts of very complex geometry. It is emphasized that the combined use of numerical and experimental methods provides a more accurate design tool for modern gas turbine engines. V.L.

A88-15186
NUMERICAL MODELING OF STATIONARY SEPARATED FLOWS
V. M. KOVENIA, V. I. PINCHUKOV, and S. G. CHERNYI (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) IN: BAIL IV; Proceedings of the Fourth International Conference on Boundary and Interior Layers - Computational and Asymptotic Methods, Novosibirsk, USSR, July 7-11, 1986 . Dun Laoghaire, Ireland, Boole Press, 1986, p. 117-129. refs

Viscous separated flows are studied in the approximation of complete and simplified Navier-Stokes (NS) equations of a compressible gas. The problem of stationary transonic flow of a viscous gas stream around an airfoil is considered, and the stationary solution of the NS equations is found by using a conservative, absolutely stable scheme based on the relaxation principle. Then, stationary flows are studied in the approximation of parabolized NS equations. C.D.

A88-15455
A NONLINEAR, ASYMPTOTIC INVESTIGATION OF THE STATIONARY MODES OF INSTABILITY OF THE THREE-DIMENSIONAL BOUNDARY LAYER ON A ROTATING DISC
SHARON MACKERRELL (Exeter, University, England) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 413, no. 1845, Oct. 8, 1987, p. 497-513. refs

There exist two types of stationary instability of the flow over a rotating disk, corresponding to the upper inviscid mode and the lower-branch mode (which has a triple-deck structure) of the neutral stability curve. The linear problem has been investigated by Hall (1986), and the asymptotic structure of the wavenumber and orientation of these modes has been obtained. Here, a nonlinear investigation of high-Reynolds-number stationary instabilities in the three-dimensional boundary layer on a rotating disk is given for the lower-branch mode. By considering nonlinear effects and following the framework set up by Hall, asymptotic solutions are obtained that enable the finite amplitude growth of a disturbance close to the neutral location to be described. Author

A88-15576
AEROSPACE AVIONICS EQUIPMENT AND INTEGRATION CONFERENCE AND EXHIBIT, PHOENIX, AZ, APR. 23, 24, 1986, PROCEEDINGS
Conference and Exhibit sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE P-179), 1986, 189 p. For individual items see A88-15577 to A88-15590.
(SAE P-179)

The design of avionics components to meet U.S. military integration standards for multiplexing, computers, and stores is examined in reviews and reports. Topics addressed include MIL-STD-1750A, MIL-STD-1553, and the high-speed data bus. Consideration is given to 1750A-1553 interface hardware, software support for 1750A expanded memory, a high-performance fiber-optic 1553B data bus, a robust 100-Mb/s fiber-optic local-area network for aerospace applications, the integrated digital avionics system for the F-20, low-cost test instrumentation for 1553-based systems, and high-speed interconnect system architecture and operation. T.K.

A88-15578
THE DEVELOPMENT OF A STANDARD ELECTRONIC MODULE WITH MIL-STD-1750A CAPABILITIES
JOSEPH P. FISCHER (McDonnell Douglas Electronics Co., Saint Charles, MO) IN: Aerospace Avionics Equipment and Integration Conference and Exhibit, Phoenix, AZ, Apr. 23, 24, 1986, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 17-22. refs
(SAE PAPER 860838)

This paper describes the development of a standard size and function electronic module to meet the requirements of aircraft technology advances and future military aircraft avionic systems. The standard electronic module developed utilizes a MIL-STD-1750A central processing unit and is designed for applications requiring a general data processor. Design goals included MIL-STD-1750A compatibility, nonvolatile, high speed memory, memory management options, interfacing to a common bus backplane, the use of surface mount technology, application of new material and process techniques, and high speed I/O and direct memory access. Second generation development of this electronic module will incorporate VHSIC technology. Author

A88-15579
ADVANCED MIL-STD-1553 UHF/VHF RADIO
PAUL F. CHRISTIANO (Northrop Corp., Advanced Systems Div., Pico Rivera, CA) IN: Aerospace Avionics Equipment and Integration Conference and Exhibit, Phoenix, AZ, Apr. 23, 24, 1986, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 23-29.
(SAE PAPER 860840)

Hardware and software for the control of multiple UHF/VHF radios aboard an aircraft via the MIL-STD-1553 data bus are described, and the system architecture is illustrated with extensive diagrams and flow charts. The system comprises independent mulitpurpose display/entry units, a bus-control processor, an audio control distribution unit, and the radios and antennas. The characteristics of the radios are reviewed, and the control operation is outlined. The use of the MIL-STD-1553 bus is shown to simplify radio operation, reduce crew intervention requirements, and provide crew and maintenance personnel with accurate information on the operating capabilities of damaged or malfunctioning radios. T.K.

A88-15581
AIRCRAFT/STORES DATA BUS NETWORKS
RICHARD A. FLANAGAN (Boeing Military Airplane Co., Wichita, KS) and DAMON G. SIMPSON (Raychem Corp., Menlo Park, CA) IN: Aerospace Avionics Equipment and Integration Conference and Exhibit, Phoenix, AZ, Apr. 23, 24, 1986, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 35-43.
(SAE PAPER 860842)

The integration of data bus military standard MIL-STD-1553 into an aircraft stores management system is unique. The number of remote terminals connected to the network is not constant. Weapons and their remote terminals are physically separated from the network during normal operation. This creates dynamic changes in the electrical loading of the network. Laboratory network integration tests were performed for both fighter and bomber single level networks. Single and multiple stores releases were simulated. Test results allow designers to understand the effects of coupler spacing, stub length and weapon releases on the performance of stores data bus networks. Author

A88-15583
AN OVERVIEW OF SAE AE-9B HIGH SPEED RING BUS (HSRB) PERFORMANCE
ROBERT J. DELCOCO, BRIAN W. KROEGER, and JOHN J. KURTZ (Westinghouse Electric Corp., Pittsburgh, PA) IN: Aerospace Avionics Equipment and Integration Conference and Exhibit, Phoenix, AZ, Apr. 23, 24, 1986, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 55-68. refs
(SAE PAPER 860844)

The design, operating principles, and theoretical performance of a standard high-speed token-passing ring bus (HSRB) are described and illustrated with diagrams and graphs. The HSRB is being developed by the SAE AE-9B subcommittee to meet future military (ship and aircraft) requirements for high-speed local-area networking. Consideration is given to priority and short-message operations, the token frame, the message-frame format, minimal-station-delay protocols, ring synchronization, and fault-recovery methods. Comparative calculations show the performance of an optimized HSRB at 100 Mb/s to be superior to that of a linear contention bus or a linear token-passing bus. If maximum and average message length are kept to 512 and 100 words, respectively, it is estimated that the HSRB can attain throughput efficiency greater than 90 percent and high-priority-message latency time less than 500 microsec. T.K.

A88-15585
UTILITIES SYSTEMS MANAGEMENT - FLYING DEMONSTRATOR
I. MOIR and P. H. CAPENER (Smiths Industries Aerospace and Defence Systems, Ltd., London, England) IN: Aerospace Avionics Equipment and Integration Conference and Exhibit, Phoenix, AZ, Apr. 23, 24, 1986, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 77-87.
(SAE PAPER 860851)

The design and operation of the utilities systems management (USM) hardware developed for the UK Experimental Aircraft Program (EAP) demonstrator are presented in extensive drawings and diagrams and briefly characterized. The USM links the basic aircraft systems (fuel, engine, environmental control, secondary power, hydraulics, etc.) to the avionics or mission bus. It comprises a dedicated MIL-STD-1553B bus, distributed data-acquisition units with local processing and control, an integrated power control, and interfaces with the multifunction displays of the digital cockpit. The overall operation of the USM is outlined; and the system implementation and packaging are discussed. Particular attention is given to the use of relays (rather than solid-state devices) for discrete power switching. When compared to conventional utilities control systems, the USM is shown to provide weight and operating-cost savings of over 50 percent and an eightfold improvement in availability. T.K.

A88-15586
SOFTWARE CONSIDERATIONS FOR INTERFACING AVIONICS COMPUTERS AND MUX BUSES
S. LLOYD PLEHATY (Norden Systems, Inc., Norwalk, CT) IN: Aerospace Avionics Equipment and Integration Conference and Exhibit, Phoenix, AZ, Apr. 23, 24, 1986, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 89-94. refs
(SAE PAPER 860853)

The impact of avionics-system complexity on the design of interface bus terminals to link MIL-STD-1750A computers with MIL-STD-1553B data buses is discussed, with a focus on software aspects. The characteristics of typical state-of-the-art avionics are reviewed, including simple synchronous systems, complex multimode systems, and asynchronous systems. Consideration is given to bus features such as message chaining, selective interrupts, automatic retry, memory addressing, I/O buffering, buffer-access conflicts, terminal control, and I/O processing. The need for standardized smart bus terminals capable of handling asynchronous I/O is stressed, and it is suggested that such standards could facilitate the development of standardized software drivers and software tools. T.K.

A88-15647
STRUCTURAL MECHANICS OF FLIGHT VEHICLES [STROITEL'NAIA MEKHANIKA LETATEL'NYKH APPARATOV]
IVAN FILIPPOVICH OBRAZTSOV, LEV ALEKSEEVICH BULYCHEV, VALERII VITAL'EVICH VASIL'EV, ANDREI NIKOLAEVICH ELPAT'EVSKII, KONSTANTIN ALEKSEEVI ZHEKOV et al. Moscow, Izdatel'stvo Mashinostroenie, 1986, 536 p. In Russian. refs

The book presents the basic concepts and methods of the structural mechanics of flight vehicles. The discussion covers variational principles and applied methods for solving problems in structural mechanics; calculation of rod systems, plates, and shells; analysis of reinforced thin-walled structures using the beam theory; and finite-element analysis of thin-walled three-dimensional structures. Other topics discussed include the fundamentals of the systems analysis of complex aircraft structures; static stability of flight vehicle elements; vibrations of flight vehicle structures; and analysis of flight vehicle structures in the case of inelastic material behavior. V.L.

A88-15706#
PRESSURE FIELD GENERATED BY JET-ON-JET IMPINGEMENT
NAGY NOSSEIR, URI PELED, and GREGORY HILDEBRAND (San Diego State University, CA) AIAA Journal (ISSN 0001-1452), vol. 25, Oct. 1987, p. 1312-1317. Previously cited in issue 22, p. 3262, Accession no. A86-45437. refs
(Contract N0014-84-K-0373)

A88-16344#
AN APPROXIMATE APPROACH TO ESTIMATE THE DYNAMIC CHARACTERISTICS OF AEROELASTIC SYSTEM
YI LU and CHENGZHONG LI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, June 1987, p. B299-B304. In Chinese, with abstract in English. refs

This paper gives a method for obtaining approximately the eigenvalues and eigenvectors of an aeroelastic system in an unsteady aerodynamic environment in an arbitrary state. The method is valid for motion with multiple degrees of freedom and extends the relationship between the decay rate of structural motion and the fictitious structural damping coefficients and frequencies of the V-g method. The calculated results show that the present method is satisfactory in estimating the dynamic characteristics of aeroelastic systems. By comparison with the p-k method, the augmented-state method, and the graphical techniques, the advantage of the proposed method is its simplicity. Author

A88-16435
STOCHASTIC MODAL INTERACTION IN LINEAR AND NONLINEAR AEROELASTIC STRUCTURES
R. A. IBRAHIM and Z. HEDAYATI (Texas Tech University, Lubbock) Probabilistic Engineering Mechanics (ISSN 0266-8920), vol. 1, Dec. 1986, p. 182-191. refs
(Contract AF-AFOSR-85-0008)

The linear, parametric, and autoparametric random responses in a three degree-of-freedom structure submitted to wide band excitation are investigated. Mean square responses are obtained for models with constant parameters and with random variations in stiffness matrix. The Fokker Planck equation method and a Gaussian closure scheme are used to determine the nonlinear random response of the system in the neighborhood of combination internal resonance. The response is shown to deviate from the linear solution when the system internal detuning is close to the exact internal resonance, and the autoparametric interaction is shown to depend on the system damping ratios and a nonlinear coupling parameter. R.R.

A88-16560*# Columbia Univ., New York, N.Y.
RESPONSE OF STIFFENED PANELS FOR APPLICATIONS TO ACOUSTIC FATIGUE
R. VAICAITIS (Columbia University, New York) and S. T. CHOI AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 12 p. refs
(Contract NAG1-541)
(AIAA PAPER 87-2711)

The surface protection systems of aerospace and aircraft structures are often constructed from discretely stiffened panels. This paper presents an analytical study on dynamic stress response of these structures to random surface flow and acoustic loads. To account for aerodynamic heating of high speed flow, thermal effects are included in the structural model. A generalized transfer matrix procedure is developed to obtain the required dynamic response solutions. Numerical results include spectral densities of stress, response root mean square values and fatigue damage for a variety of loading and thermal conditions. Author

A88-16561*# Analytical Services and Materials, Inc., Hampton, Va.
MULTIPLE-MODE LARGE DEFLECTION RANDOM RESPONSE OF BEAMS WITH NONLINEAR DAMPING SUBJECTED TO ACOUSTIC EXCITATION
C. B. PRASAD (Analytical Services and Materials, Inc., Hampton, VA) and CHUH MEI (Old Dominion University, Norfolk, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 18 p. refs
(Contract NAS1-17993)
(AIAA PAPER 87-2712)

Multiple-mode nonlinear analysis is carried out for beams subjected to acoustic excitation. Effects of both nonlinear damping and large-deflection are included in the analysis in an attempt to explain the experimental phenomena of aircraft panels excited at high sound pressure levels; that is the broadening of the strain response peaks and the increase of modal frequency. An amplitude dependent nonlinear damping model is used in the anlaysis to study the effects and interactions of multiple modes, nonlinear stiffness and nonlinear damping on the random response of beams. Mean square maximum deflection, mean square maximum strain, and spectral density function of maximum strain for simple supported and clamped beams are obtained. It is shown analytically that nonlinear damping contributes significantly to the broadening of the response peak and to the mean square deflection and strain. Author

A88-16562*# Old Dominion Univ., Norfolk, Va.
A FINITE ELEMENT LARGE DEFLECTION RANDOM RESPONSE ANALYSIS OF BEAMS AND PLATES SUBJECTED TO ACOUSTIC LOADING
CHUH MEI (Old Dominion University, Norfolk, VA) and C. K. CHIANG AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 11 p. refs
(Contract F33615-86-C-3230; NAS1-17993)
(AIAA PAPER 87-2713)

A finite element formulation is presented for the analysis of beams and rectangular plates undergoing large deflections subjected to Gaussian white noise excitations. Single-mode response is assumed in the present formulation. Root-mean-square (RMS) maximum deflections for simply supported and clamped beams and plates at various sound spectrum levels are obtained and compared with solutions using the Fokker-Planck-Kolmogorov equation and the equivalent linearization methods. RMS maximum stains and equivalent linear frequencies are compared with the equivalent linearization results for assessment of the accuracy of the finite element method. Author

A88-16573#
VIBRATION ANALYSIS OF FLAT SKIN-STRINGER STRUCTURES BY THE SUPER MATRIX METHOD
G. COMTE-BELLOT, B. GAY (Lyon, Ecole Centrale, Ecully, France), and C. FRANCO (Framatome, Paris-la-Defense, France) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. Research sponsored by Aerospatiale. refs
(AIAA PAPER 87-2734)

The super matrix method is presented as a technique for analyzing the forced vibrations of large stiffened structures composed of panels and stringers such as airplane fuselages. It is shown that this method can produce accurate modal forms in structures of up to 21 panels. External excitation can be concentrated or distributed as in the case of propagating acoustic waves. Applications concern aircraft cabin noise. Author

A88-16586#
JET IMPINGEMENT HEAT TRANSFER - A LITERATURE SURVEY
S. J. DOWNS (Rolls-Royce, PLC, Derby, England) and E. H. JAMES (Loughborough University of Technology, England) ASME, AIChE, and ANS, National Heat Transfer Conference and Exhibition, 24th, Pittsburgh, PA, Aug. 9-12, 1987. 11 p. refs
(ASME PAPER 87-HT-35)

A literature survey had been carried out as part of background investigations relating to research by the author. The search was biased towards obtaining information concerning the heat transfer characteristics of round impinging jets, although slot nozzles were covered where relevant as were nonimpinging jets. This paper summarizes the findings of the literature review, covering forty-seven papers describing experimental investigations and theoretical analyses. Author

A88-16678
THE USE OF SPEECH TECHNOLOGY IN AIR TRAFFIC CONTROL SIMULATORS
J. A. HARRISON, G. R. HOBBS, J. R. HOWES, and N. COPE (Ferranti Computer Systems, Ltd., Bracknell, England) IN: International Conference on Simulators, 2nd, Coventry, England, Sept. 7-11, 1986, Proceedings . London, Institution of Electrical Engineers, 1986, p. 15-19.

The advantages of applying speech technology to air traffic control (ATC) simulators are discussed with emphasis placed on the simulation of the pilot end of the pilot-controller dialog. Speech I/O in an ATC simulator is described as well as technology capability, and research on an electronic blip driver. It is found that the system is easier to use and performs better for less experienced controllers. K.K.

A88-16747#
HEAT REMOVAL KEY TO SHRINKING AVIONICS
GEORGE P. PETERSON (Texas A & M University, College Station) Aerospace America (ISSN 0740-722X), vol. 25, Oct. 1987, p. 20-22.

An evaluation is made of the consequences for avionics miniaturization and performance improvement of recent advancements in heat pipe technology. In a heat pipe, the phase change of a working fluid can yield levels of thermal conductivity that are several orders of magnitude greater than solid conductors. Current interest extends to large heat pipes (0.3 m or greater in length), medium-sized heat pipes on which electronic components are mounted, and microheat pipes, whose dimensions are of the order of 5 cm length and 1 mm diameter. O.C.

N88-11886# Joint Publications Research Service, Arlington, Va.
THREE-DIMENSIONAL CALCULATION IN HIGH SUBSONIC AXIAL COMPRESSOR ROTOR AND ITS COMPARISON WITH L2F VELOCITY MEASUREMENT Abstract Only
QINGHUAN WANG *In its* JPRS report: Science and Technology. China p 32 14 Jul. 1987 Transl. into ENGLISH from Gongcheng Rewuli Xuebao (Beijing, Peoples Republic of China), v. 8, no. 2, May 1987 p 119-124 Original language document was announced in IAA as A87-51809
Avail: NTIS HC A07/MF A01

As a part of the basic research program to increase the understanding of the internal flow in high subsonic and transonic flow compressors and to improve the design and analysis calculation methods, a two-focus laser velocimeter has been employed in measuring the velocity and the flow angles in a compressor rotor running at peak efficiency points of several partial design speeds. Three-dimensional flow calculation has also been undertaken for these off-design conditions. The outlet velocity measured by the velocimeter, outlet stagnation pressure measured by pitot tubes, and isentropic rotor efficiency measured by a phase difference torquemeter are used as input values to the theoretical calculation. The variation of flow on the S (2m) surface and on the S1 surfaces, as measured by the velocimeter, agrees reasonably well with the calculated variation. This indicates that the three dimensional calculation method used can give a good picture of the internal flow in the compressor rotor. Author

N88-11926# European Space Agency, Paris (France).
A CONFORMAL AIRCRAFT PHASED ARRAY ANTENNA FOR AIRPLANE-SATELLITE COMMUNICATION IN THE L BAND
GEORG SPLITT and HANS FORSTER Jun. 1987 94 p Transl. into ENGLISH of Eine Konforme Flugzeug-Array-Antenne mit Schwenkbarer Strahlungscharakteristik zur Satellitenkommunikation im L-Band (Oberpfaffenhofen, Fed. Republic of Germay, DFVLR), Sep. 1986 Original language document was announced as N87-26259
(ESA-TT-1057; DFVLR-FB-86-47; ETN-87-90876) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, Cologne, Fed. Republic of Germany DM 34

A medium gain antenna was developed for direct reception of the MARECS satellite. The antenna system is conformal with the outer skin of the airplane. It was designed as a phased-array system consisting of six individual elements placed in a vertical row. The radiation pattern can be moved in elevation, and can thus be pointed towards the satellite. The halfwidth in elevation direction is 17 deg arc, and in azimuthal direction 20 deg arc. The measurements show a gain between 9 and 10.8 dBi, depending on the lobe, and an efficiency of 65%. The suppression of the mirror reflection by the antenna diagram is between -20 and -25 dB. ESA

N88-12010# Fujitsu Ltd., Tokyo (Japan). Scientific Systems Dept.
ON THE SCHEME DEPENDENCY OF THE THREE-DIMENSIONAL EULER SOLUTIONS
YOKO TAKAKURA, TOMIKO ISHIGURO, and SATORU OGAWA (National Aerospace Lab., Tokyo, Japan) *In* Tokyo Univ., The Proceedings of the Symposium on Mechanics for Space Flight p 31-45 Mar. 1987
Avail: NTIS HC A09/MF A01

The modification of the recent total variation diminishing (TVD) schemes with regard to treatment of metric is presented, and the estimation for the TVD schemes and the conventional Beam-Warming scheme is performed by comparing the computational results for the three-dimensional flows about the ONERA-M6 wing with the experimental data. Modified TVD schemes are proved to be reasonable when applied to the three-dimensional Euler equation in general curvilinear coordinates and the characteristics of each scheme have been captured. It was verified for each scheme that it should be made to agree with accuracy of fluxes; otherwise, modification of maintaining freestream should be used. The modified TVD schemes yield excellent solutions with few numerical oscillations for even strong shock waves and a high ability of capturing the leading edge expansion and weak shock waves. The negative side is high cost and inapplicability to three-dimensional problems because weak shock waves are missed. Author

N88-12011# IBM Japan. Technical Education.
NUMERICAL STUDY OF THE ENTRANCE FLOW AND ITS TRANSITION IN A CIRCULAR PIPE (2)
H. KANDA and K. OSHIMA *In* Tokyo Univ., The Proceedings of the Symposium on Mechanics for Space Flight p 47-76 Mar. 1987
Avail: NTIS HC A09/MF A01

The experimental data and results of prior investigations lead to defining the problem of the transition from laminar to turbulent flow in a circular pipe. The flow field of a circular pipe is examined with particular emphasis on the entrance and transition length, using a two-dimensional computational scheme. Symmetric disturbances were superimposed on points near the inlet and wall of the pipe. It was found for the first time that the transition length is predicted fairly satisfactorily by the computational simulation. A numerical, finite-difference method is shown to simulate development of the Hagen-Poiseuille flow and transition to turbulent flow. Conclusions are: (1) the turbulence transition occurs only within the entrance region; (2) the transition length decreases as the Reynolds number increases under the same inlet conditions; (3) a good bellmouth lessens disturbances at the inlet and the critical Reynolds number becomes larger; (4) the transition is numerically simulated on the conditions that the aspect ratios of the rectangular mesh system are 2 for Re=2,700 and 1 for Re=10,000 and that the disturbance is given at the point very near the wall of the inlet; and (5) the result of simulation satisfies two theorems of Rayleigh (dependence of the flow stability on laminar velocity profiles). Author

N88-12038# Dayton Univ., Ohio.
STUDY OF AEROPROPULSION LABORATORY PRESSURE DROP RIG AND RECOMMENDED TEST PROCEDURE Final Report, May - Oct. 1984
M. O. LAWSON and J. E. MINARDI Nov. 1986 58 p
(Contract F33615-84-C-2411)
(AD-A184333; UDR-TR-84-139; AFWAL-TR-86-2077) Avail: NTIS HC A04/MF A01 CSCL 14B

This report presents the results of a study of a pressure drop rig for measuring pressure drop across samples of foam. In addition, a test procedure and two evaluation programs are presented which reduce test data to standard day conditions so that the results are independent of the test ambient conditions. An analysis of instrument reading error effects is provided to determine their maximum cumulative effect on the assigned value of foam pressure drop. GRA

N88-12114# European Space Agency, Paris (France).
CRACK INITIATION AND PROPAGATION DUE TO CYCLIC THERMAL GRADIENTS
PIERRE-MARIE LESNE Sep. 1987 182 p Transl. into ENGLISH of Amorcage et Propagation de Fissures sous Gradients Thermiques Cycliques (Chatillon, France) Original language document was previously announced as N87-13829
(ESA-TT-1023; ONERA-P-1985-2; ETN-87-91112) Avail: NTIS HC A09/MF A01

Tests were made on a simple thin plate of IN100 superalloy approximating the shape of a turbine blade, in which crack initiation and propagation by thermal fatigue were produced, to develop a method for predicting the creep-fatigue lifetime of such structures under variable temperature conditions. A finite element method including cyclic viscoplastic constitutive equations was used to calculate the stresses and plastic strains at every point on the blade at successive cycles, using the temperature distribution maps and variable-temperature constitutive equations as given data. The crack initiation can be calculated from the variable-temperature fatigue damage and creep laws, using the hysteresis loop at the stabilized (12th) cycle. Crack propagation, carefully measured during the tests, is predicted by a method based on linear fracture mechanics, taking the viscoplastic behavior of the material into account. The calculation/test comparison is good for initiation and propagation. ESA

N88-12617*# Sundstrand Corp., Rockford, Ill. Energy Systems.
A STUDY OF TWO-PHASE FLOW IN A REDUCED GRAVITY ENVIRONMENT Final Report
D. HILL and ROBERT S. DOWNING 16 Oct. 1987 173 p
(Contract NAS9-17195)
(NASA-CR-172035; NAS 1.26:172035; DRL-T-1884; DRD-TM-478T) Avail: NTIS HC A08/MF A01 CSCL 22A

A test loop was designed and fabricated for observing and measuring pressure drops of two-phase flow in reduced gravity. The portable flow test loop was then tested aboard the NASA-JSC KC135 reduced gravity aircraft. The test loop employed the Sundstrand Two-Phase Thermal Management System (TPTMS) concept which was specially fitted with a clear two-phase return line and condenser cover for flow observation. A two-phase (liquid/vapor) mixture was produced by pumping nearly saturated liquid through an evaporator and adding heat via electric heaters. The quality of the two-phase flow was varied by changing the evaporator heat load. The test loop was operated on the ground before and after the KC135 flight tests to create a one-gravity data base. The ground testing included all the test points run during the reduced gravity testing. Two days of reduced gravity tests aboard the KC135 were performed. During the flight tests, reduced-gravity, one-gravity, and nearly two-gravity accelerations were experienced. Data was taken during the entire flight which provided flow regime and pressure drop data for the three operating conditions. The test results show that two-phase pressure drops and flow regimes can be accurately predicted in zero-gravity.
Author

N88-12634# Joint Publications Research Service, Arlington, Va.
EXCITATION OF NATURAL OSCILLATIONS OF A BOUNDARY LAYER BY AN EXTERNAL ACOUSTIC FIELD Abstract Only
A. A. MASLOV and N. V. SEMENOV *In its* USSR Report: Engineering and Equipment p 92 28 May 1987 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 3, May - Jun. 1986 p 74-78 Previously announced as X87-71990
Avail: NTIS HC A06/MF A01

Experimental studies of the susceptibility of the supersonic boundary layer to undergo the transition from laminar to turbulent flow were undertaken. It was found that there are areas on the plate of most effective conversion of external acoustic disturbances to natural oscillations of the supersonic boundary layer. The leading edge of the plate, acoustical branch of the neutral curve and lower branch of the curve of neutral stability are such areas. Experiments were performed in a T-325 supersonic wind tunnel with reduced turbulence in a 200 by 200 mm cross-section.
Author

N88-12636# Joint Publications Research Service, Arlington, Va.
DYNAMICS OF REVERSE FLOWS AT PUMP INLET Abstract Only
N. S. YERSHOV *In its* USSR Report: Engineering and Equipment p 93 28 May 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 4, Oct. - Dec. 1985 p 49-53
Avail: NTIS HC A06/MF A01

Under stationary conditions, due to the effect of cavitation on the aerodynamics between the blading and the flow, the length of the zone of reverse flows decreases and the field of velocities in each section is distorted. The boundary of reverse flows is a place where the reverse flow and an unperturbed flow meet at the inlet pipe wall. An equation was derived that gives a mathematical description of a phenomenon which was observed in the case of self-excited oscillations, when at a certain stage of the process the length of the reverse flows increases. This phenomenon was in contradiction with earlier conceptions. The derived equations could be used for construction of a pump operating with reverse flows. Author

N88-12791# Air Force Academy, Colo.
CALCULATION OF THE TRIBOLOGICAL PROPERTIES OF SURFACES BY SEMI-EMPIRICAL METHODS
JON T. SWANSON and JAMES J. STEWART Jul. 1987 10 p
(AD-A184283; FJSRL-TR-87-0005) Avail: NTIS HC A02/MF A01 CSCL 11H

One method of increasing the performance of aircraft engines is to operate the engines at higher temperatures. A critical technology in this application is lubrication at high temperatures. A thorough understanding of solid lubrication of ceramic materials is therefore required. This report details our initial attempts at preparing a semi-empirical quantum chemical model of solid lubricants. In our initial study we focused on two areas of the problem. The first area was to determine the best approach to treating a model surface or lubricant. The selection was governed by providing a reasonable model without requiring an unreasonable amount of computer time for each calculation. The second area concerned obtaining an estimate of the ability of the above models to calculate the relatively weak interactions which occur between surfaces and lubricants, and between the lubricants themselves. Our first concern was to reproduce the trends, rather than obtain the absolute values in these interactions. GRA

N88-12796*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASURED PERFORMANCE OF THE HEAT EXCHANGER IN THE NASA ICING RESEARCH TUNNEL UNDER SEVERE ICING AND DRY-AIR CONDITIONS
W. OLSEN, J. VANFOSSEN, and R. NUSSLE Dec. 1987 29 p
(NASA-TM-100116; E-3661; NAS 1.15:100116) Avail: NTIS HC A03/MF A01 CSCL 13I

Measurements were made of the pressure drop and thermal perfomance of the unique refrigeration heat exchanger in the NASA Lewis Icing Research Tunnel (IRT) under severe icing and frosting conditions and also with dry air. This data will be useful to those planning to use or extend the capability of the IRT and other icing facilities (e.g., the Altitude Wind Tunnel-AWT). The IRT heat exchanger and refrigeration system is able to cool air passing through the test section down to at least a total temperature of -30 C (well below icing requirements), and usually up to -2 C. The system maintains a uniform temperature across the test section at all airspeeds, which is more difficult and time consuming at low airspeeds, at high temperatures, and on hot, humid days when the cooling towers are less efficient. The very small surfaces of the heat exchanger prevent any icing cloud droplets from passing through it and going through the tests section again. The IRT heat exchanger was originally designed not to be adversely affected by severe icing. During a worst-case icing test the heat exchanger iced up enough so that the temperature uniformaity was no worse

than about +/- 1 deg C. The conclusion is that the heat exchanger design performs well. Author

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A88-13261
CHARGE SIMULATION METHOD FOR THE CALCULATION OF ELECTROMAGNETIC FIELDS RADIATED FROM LIGHTNING
P. RATNAMAHILAN, P. HOOLE (Oxford University, England), S. RATNAJEEVAN, and H. HOOLE (Drexel University, Philadelphia, PA) IN: Betech 86; Proceedings of the Second Boundary Element Technology Conference, Cambridge, MA, June 17-19, 1986 . Southampton, England and Billerica, MA, Computational Mechanics Publications, 1986, p. 153-169. Research supported by the Culham Lightning Club. refs

Lightning is an electrical phenomenon in which many physical processes combine to produce the majestic flash. The modeling of the leader and return strokes requires good electromagnetic field calculation methods to test the model as well as to determine fields at any point in space and time. The well known charge simulation method could be directly used for leader stroke computations. An extension of the principles of the method is presented here to determine the transient fields radiated from lightning return strokes. The method is simple to use, shown to give accurate results, and may be applied to branched lightning. Author

N88-12897*# Electro Magnetic Applications, Inc., Denver, Colo.
EXPERIMENTAL AND ANALYTIC STUDIES OF THE TRIGGERED LIGHTNING ENVIRONMENT OF THE F106B
TERENCE RUDOLPH, CALVIN C. EASTERBROOK, POH H. NG, ROBERT W. HAUPT, and RODNEY A. PERALA Washington Dec. 1987 122 p
(Contract NAS1-17748)
(NASA-CR-4104; NAS 1.26:4104; EMA-87-R-37) Avail: NTIS HC A06/MF A01 CSCL 04B

The triggered lightning environment of the F106B aircraft is investigated. Scale modeling of the F106B with a metallized model was done to measure electric field enhancement factors on the aircraft and on canonically shaped conducting objects. These are then compared to numerically determined quantities. Detailed numerical modeling is done of the development of the triggered lightning channel. This is done using nonlinear air chemistry models to model a variety of physical phenomena which occur in a triggered lightning event. The effect of a triggered lightning strike on internal wires in the F106B is investigated using finite difference models and transmission line models to calculate the electromagnetic coupling of lightning currents through seams and joints of the aircraft to internal cables. Time domain waveforms are computed and compared to measured waveforms. The effect of thunderstorm particles on the initial triggering of a lightning strike is investigated. The electric field levels needed to cause air breakdown in the presence and absence of thunderstorm particles are calculated. This is done as a function of the size, shape, and density of the particles. Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A88-13257
BETECH 86; PROCEEDINGS OF THE SECOND BOUNDARY ELEMENT TECHNOLOGY CONFERENCE, MIT, CAMBRIDGE, MA, JUNE 17-19, 1986
J. J. CONNOR, ED. (MIT, Cambridge, MA) and C. A. BREBBIA, ED. (Computational Mechanics Institute, Southampton, England) Southampton, England and Billerica, MA, Computational Mechanics Publications, 1986, 837 p. For individual items see A88-13258 to A88-13283.

Papers are presented on the role of boundary elements in CIM, boundary elements for high intensity electric field computation in scientific instruments, a charge simulation method for the calculation of electromagnetic fields, and new developments in coupled thermoelastic analysis by BEM. Also considered are a boundary element formulation of steady heat transfer of thin plates, a boundary element approach to a free-wake analysis of helicopter rotors, and potential hydrodynamic effects on structures by the BEM. Other topics include BEM for laminar motion of isochoric viscous flows, BEM in elastic torsional problems using Green's generalized theorem and R-functions, and an indirect boundary integral equation for spherical shells. Papers are also presented on cracks at stress concentrators, a boundary element technique for poroelasticity, shape optmization utilizing a boundary element formulation, and some experimental results with nonconforming elements. R.R.

A88-13926* Princeton Univ., N. J.
REAL-TIME OPERATIONAL PLANNING FOR THE U.S. AIR TRAFFIC SYSTEM
JOHN M. MULVEY (Princeton University, NJ) and STAVROS A. ZENIOS (Pennsylvania, University, Philadelphia) Applied Numerical Mathematics (ISSN 0168-9274), vol. 3, Oct. 1987, p. 427-441. Research supported by the Alfred P. Sloan Foundation. refs
(Contract NSF DCR-84-01098; NAG1-520)

This paper describes an integrated planning model for the U.S. air traffic system. The approach incorporates the dual objectives of monitoring collision risk while minimizing transportation costs. Specialized solution algorithms exploit the underlying structure of the model - especially for large-scale examples. The proposed formulation is tested with real-world data for the Indianapolis control sector. Additional experiments with a CRAY X-MP/24 supercomputer show that a full-scale model can be solved under real time conditions. Despite these advances, additional work is required in developing a practical system. Suggestions are made for combining advances in computer graphics and mathematical modeling. Author

A88-14101
APPLICATIONS OF PARALLEL PROCESSING IN FLUID MECHANICS; PROCEEDINGS OF THE APPLIED MECHANICS, BIOENGINEERING, AND FLUIDS ENGINEERING CONFERENCE, CINCINNATI, OH, JUNE 14-17, 1987
OKTAY BAYSAL, ED. (Old Dominion University, Norfolk, VA) Conference sponsored by ASME. New York, American Society of Mechanical Engineers, 1987, 97 p. For individual items see A88-14102 to A88-14110.

Recent advances in methods, algorithms, and applications of parallel processing in fluid mechanics are discussed in reviews and reports. Topics addressed include vectorizable implicit algorithms for the flux-difference split three-dimensional Navier-Stokes equations, microtasking of fluid-mechanics codes on an XM-P supercomputer, and supercomputing of supersonic

flows using upwind relaxation and MacCormack schemes. Consideration is given to the accuracy, geometrical flexibility, and vectorizability of the finite-difference method; a parallel compressible-flow algorithm for multiprocessors; performance of a three-dimensional Navier-Stokes code for high-speed juncture flows; computation of subsonic base flow on a vector processor; and multitasking for flows around multibody configurations using a chimera grid scheme. T.K.

A88-14103*# Vigyan Research Associates, Inc., Hampton, Va.
VECTORIZABLE IMPLICIT ALGORITHMS FOR THE FLUX-DIFFERENCE SPLIT, THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS
P. M. HARTWICH (Vigyan Research Associates, Inc., Hampton, VA), C.-H. HSU (Kansas, University, Lawrence), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) IN: Applications of parallel processing in fluid mechanics; Proceedings of the Applied Mechanics, Bioengineering, and Fluids Engineering Conference, Cincinnati, OH, June 14-17, 1987 . New York, American Society of Mechanical Engineers, 1987, p. 9-18. refs
(Contract NAS1-17919; NAG1-455)

The computational efficiency of four vectorizable implicit algorithms is assessed when applied to calculate steady-state solutions to the three-dimensional, incompressible Navier-Stokes equations in general coordinates. Two of these algorithms are characterized as hybrid schemes; that is, they combine some approximate factorization in two coordinate directions with relaxation in the remaining spatial direction. The other two algorithms utilize an approximate factorization approach which yields two-factor algorithms for three-dimensional systems. All four algorithms are implemented in identical high-resolution upwind schemes for the flux-difference split Navier-Stokes equations. These highly nonlinear schemes are obtained by extending an implicit Total Variation Diminishing (TVD) scheme recently developed for linear one-dimensional systems of hyperbolic conservation laws to the three-dimensional Navier-Stokes equations. The computation of vortical flow over a sharp-edged, thin delta wing has been chosen as a common numerical test case. The convergence of the algorithms is discussed and the accuracy of the computed flow-field results is assessed. The validity of the present results are demonstrated by a comparison with experimental data. Author

A88-14255#
USING MICROCOMPUTERS AND SPECIALIZED SOFTWARE TO ENHANCE AIRCRAFT DESIGN EDUCATION
ROBERT F. DAVEY (California State Polytechnic University, Pomona) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 7 p.
(AIAA PAPER 87-2866)

A new educational technique is described which provide the undergraduate engineering student with realistic design experiences while maintaining a clear link with the associated engineering principles. Using specially developed software and microcomputers, the method develops in the student the ability to evaluate the validity of computer-generated designs and performance predictions. Criteria are established for the required software and its usage and the results of a test case are reported. The application described uses special airfoil-analysis software for a series of design exercises which culminate in a requirement to establish performance goals and then develop an airfoil to meet them. After completing the assignments, the students' ability to relate the physical features of an airfoil shape to the predicted performance is clearly superior to that of students instructed using more traditional methods. Author

A88-14264#
GEOMETRY PROCESSING
ROBERT E. BARNHILL (Arizona State University, Tempe) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 5 p. Research supported by the Lockheed-California Co. and Control Data Corp. refs
(Contract DE-FG02-87ER-25041; NSF DCR-85-02858)
(AIAA PAPER 87-2898)

Geometry processing is the extraction of geometric features from an already constructed curve or surface. Four examples of geometry processing, and new algorithms for their calculation, are presented: curve smoothing, surface/surface intersection, offset surfaces, and mass properties. The fourth topic is discussed in detail, including the use of adaptive numerical integration rules and computer graphics to develop a new algorithm for practical problems. Author

A88-14265#
A GEOMETRY SYSTEM FOR AERODYNAMIC DESIGN
DAVID K. SNEPP and ROGER C. POMEROY (Boeing Commercial Airplane Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 8 p. refs
(AIAA PAPER 87-2902)

The Aero Grid and Paneling System (AGPS) is an interactive, three-dimensional surface geometry graphics system furnishing aerodynamicists with the means to define aircraft surfaces. AGPS has built-in and user-programmable features for the extraction of geometric data in a form that is appropriate for use by CFD and other analysis codes. The results thus obtained can be recovered by AGPS and displayed graphically with the surface geometry data in fully integrated fashion. A minicomputer or engineering workstation allows AGPS to represent cubic, quintic, and rational b-spline mathematics to represent curves and surfaces. O.C.

A88-14267#
PROJECT MANAGEMENT ISSUES AND LESSONS LEARNED FROM COMPUTER AIDED DESIGN APPLICATIONS
J. J. DAUES (McDonnell Douglas Corp., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 6 p.
(AIAA PAPER 87-2912)

An account is given of the development status and prospective capabilities of proprietary computer graphics programs for future automated factories, with attention to social/organizational, technology assessment, and human resource issues. Critical factors in the performance of these graphics programs are identified as the maximization of personnel colocation, the definition of manufacturing approaches, and the exclusive use of three-dimensional coordination, with emphasis on the maximization of three-dimensional outputs. Computer graphics projection rooms for design reviews should be provided. O.C.

A88-14271*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN AND VALIDATION OF FAULT-TOLERANT FLIGHT SYSTEMS
GEORGE B. FINELLI and DANIEL L. PALUMBO (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 8 p. refs
(AIAA PAPER 87-2923)

NASA has undertaken the development of a methodology for the design of easily validated fault-tolerant systems which emphasizes validation processes that can be directly incorporated into the design process. Attention is presently given to the statistical issues arising in the validation of highly reliable fault-tolerant systems. Structured specification and design methodologies, mathematical proof techniques, analytical modeling, simulation/emulation, and physical testing, are all discussed. Important design factors associated with fault-tolerance are noted; synchronization and 'Byzantine resilience' must accompany fault tolerance. O.C.

A88-14945
FUTURE DIRECTIONS IN L(INFINITY) ROBUST CONTROL THEORY
MICHAEL G. SAFONOV (Southern California, University, Los Angeles, CA) IN: IEEE Conference on Decision and Control, 25th, Athens, Greece, Dec. 10-12, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 375-378. refs

This paper presents a perspective on the L(infinity)/conic-sector/ singular-value theory for robust control system analysis and design. Included is a brief survey of the state-of-the-art and its shortcomings. The paper discusses some of the ongoing efforts to resolve the shoftcomings and expand the scope of applicability of the L(infinity) theory, including the using of conformal mappings and diagonal scalings to reduce the conservativeness of L(infinity) synthesis, the needs for nonconic robustness analysis/synthesis, robust adaptive control, decentralized robust design and control, etc. Author

A88-16468
MATERIALS AND MANUFACTURING IN AEROSPACE
A. CLEMENTSON (British Aerospace, PLC, London, England) Aerospace Dynamics (ISSN 0263-2012), no. 22, 1987, p. 2-6.

The history of materials intended for aerospace applications and the fabrication techniques of these materials is reviewed, with emphasis on the advantages and limitations of carbon fiber composites (CFC). Numerically controlled NC integral machining methods and sheet manufacturing methods are considered. SPF/DB processing with Ti-6A1-4V has yielded cost and weight savings and the production of components with close geometrical consistency. Aluminum lithium alloys have achieved density savings of 10 percent and elastic modulus increases of 10 percent. Other topics considered include the advantages of suppliers, users, and supporting groups working together, recent changes in the organizational boundaries between the technical and production activities related to these materials, and synergistic effects amongst the general production systems concepts. R.R.

A88-16685
THE FUTURE OF FLIGHT SIMULATION
STEVE SEIDENSTICKER (Logicon, Inc., San Diego, CA) IN: International Conference on Simulators, 2nd, Coventry, England, Sept. 7-11, 1986, Proceedings . London, Institution of Electrical Engineers, 1986, p. 133-137.

Some of the requirements and challenges that face the flight simulation industry are explored and the application of various technical developments to future simulators is described. An underlying architecture, based on a high capacity local area network that will function as a universal interface between all major components of a flight simulator is presented. An extension of this interface will link whole simulators. The USAF Modularity Program, designed to establish basic architectures and standards for advanced simulator design, is described. K.K.

N88-12928*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATIONS OF THE HYBRID AUTOMATED RELIABILITY PREDICTOR
SALVATORE J. BAVUSO, JOANNE BECHTA DUGAN, KISHOR T. TRIVEDI, BETH ROTHMANN, and MARK BOYD (Duke Univ., Durham, N. C.) 1987 31 p
(NASA-TP-2760; L-16304; NAS 1.60:2760) Avail: NTIS HC A03/MF A01 CSCL 12A

The Hybrid Automated Reliability Predictor (HARP) is a software package that implements advanced reliability modeling techniques. An overview is presented of some of the problems that arise in modeling highly reliable fault-tolerant systems, loosely divided into model construction and model solution problems. Then described is the HARP approach to these difficulties, which is facilitated by a technique called behavioral decomposition. The bulk of the paper presents examples of the evaluation of some typical fault tolerant systems, including a local area network, two fault-tolerant computer systems (Carnegie-Mellon University multiprocessor system C.mmp, and Software Implemented Fault Tolerance (SIFT)), and two examples of flight control systems. Author

N88-12931# National Aeronautical Lab., Bangalore (India). Fluid Mechanics Div.
NCSU CODE: VALIDATION AND EXTENSION ON NAL'S UNIVAC 1100/60 SYSTEM
P. RAMAMOORTHY and K. DHANALAKSHMI May 1987 28 p (PD-FM-8716) Avail: NTIS HC A03/MF A01

An existing computer program for obtaining the pressures on an airfoil (called here NCSU CODE) is validated on the UNIVAC 1100/60 at Canada's National Aeronautical Laboratory. A graphic routine to plot the results is added to the program to enhance its utility. The code is tried on a large number of airfoils including the modern general aviation and natural laminar airfoils. Results agree quite well with experiment; one should realize, however, that such a comparison is between the calculation in a free jet with experiments in tunnels of different blockage ratios and free stream turbulence. Author

N88-12932*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CGI DELAY COMPENSATION
RICHARD E. MCFARLAND Jan. 1986 30 p Previously announced in IAA as A86-37194
(NASA-TM-86703; REPT-85168; NAS 1.15:86703) Avail: NTIS HC A03/MF A01 CSCL 09B

Computer-generated graphics in real-time helicopter simulation produces objectionable scene-presentation time delays. In the flight simulation laboratory at Ames Research Center, it has been determined that these delays have an adverse influence on pilot performance during aggressive tasks such as nap-of-the-earth (NOE) maneuvers. Using contemporary equipment, computer-generated image (CGI) time delays are an unavoidable consequence of the operations required for scene generation. However, providing that magnitide distortions at higher frequencies are tolerable, delay compensation is possible over a restricted frequency range. This range, assumed to have an upper limit of perhaps 10 or 15 rad/sec, conforms approximately to the bandwidth associated with helicopter handling qualities research. A compensation algorithm is introduced here and evaluated in terms of tradeoffs in frequency responses. The algorithm has a discrete basis and accommodates both a large, constant transport delay interval and a periodic delay interval, as associated with asynchronous operations. Author

N88-12970# Eurocontrol Experimental Centre, Bretigny (France).
EXPERIMENTAL USE OF ARTIFICIAL INTELLIGENCE FOR (FUTURE) ATC SYSTEMS
F. KRELLA 15 Sep. 1986 52 p
(PB87-106449; EEC/NOTE-15/86) Avail: NTIS HC E04/MF E04 CSCL 09B

An expert system shell and an expert system were implemented on an IBM compatible mainframe computer. The expert system represents a planning position of an air traffic controller suite, where aircraft conflicts are resolved prior to entry in a control zone by height separation. The expert system's findings are represented on a graphical screen. The planning position corresponds to an implementation made for a real time simulation, CAPE, the computer aided planning experiment. GRA

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A88-13936
THE ACTIVE MINIMIZATION OF HARMONIC ENCLOSED SOUND FIELDS. I - THEORY. II - A COMPUTER SIMULATION. III - EXPERIMENTAL VERIFICATION
P. A. NELSON, A. R. D. CURTIS, S. J. ELLIOTT, and A. J. BULLMORE (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 117, Aug. 22, 1987, p. 1-13, 15-33, 35-58. Research supported by the Ministry of Trade and Industry and SERC. refs

The suppression of internal sound fields by secondary sound sources is investigated theoretically and experimentally. The case of a lightly damped enclosure excited by a primary point source at a frequency above the Schroeder cutoff is considered. It is shown analytically that Ep (the total time-averaged acoustical potential energy of the secondary sources) can be significantly reduced if the secondary sources are no more than half a wavelength from the point source. In numerical simulations, Ep reductions are obtained by minimizing the pressure at the maximum of the primary field or at the corners of the enclosure (for responses dominated by one mode or by two or three modes, respectively). The results of experiments with a very shallow enclosure are found to be in good general agreement with the simulations. Large reductions are obtained only when the enclosure is excited on resonance. These findings are applicable to cabin noise reduction in advanced propeller/propfan-driven midrange passenger aircraft. T.K.

A88-16472
A SIMPLE PROCEDURE FOR TRACKING FAST MANEUVERING AIRCRAFT USING SPATIALLY DISTRIBUTED ACOUSTIC SENSORS
F. M. DOMMERMUTH (Forschungsgesellschaft fuer Angewandte Naturwissenschaften, Forschungsinstitut fuer Hochfrequenzphysik, Wachtberg-Werthhoven, Federal Republic of Germany) Acoustical Society of America, Journal (ISSN 0001-4966), vol. 82, Oct. 1987, p. 1418-1424. refs

Acoustical tracking of maneuvering aircraft based on bearing measurements from distributed sensors is not directly accessible to conventional techniques because of the retardation between emission and reception of sound. To overcome this complication, the following two-step strategy is proposed: (1) Estimate the aircraft location at an arbitrary time and repeat this procedure to obtain a sequence of position estimates; (2) combine these estimates by conventional filtering methods. Focusing on the first step, the localization problem is treated on the basis of at least two separated sensors that measure the direction of arrival of the incident sound wave. An assessment of the accuracy of the resulting position estimates is provided, as well. The procedure is illustrated both with simulated and real data. Author

A88-16526*# Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn.
NOISE CHARACTERISTICS OF MODEL COUNTER-ROTATING PROP-FANS
B. MAGLIOZZI (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 14 p. refs
(Contract NAS3-24222)
(AIAA PAPER 87-2656)

Results of acoustics tests of 24.5 in. diameter model counter-rotating propfans are presented. In these tests several configurations were investigated, including tractors and pushers downstream of a pylon, both at zero degrees and at four degrees angle-of-attack. The effects on noise of spacing between rotors and between the pylon and the rotors were also measured. Effects of rotor spacing were found to cause small changes in noise. Increasing blade count from 5-front and 5-rear to 6-front and 6-rear results in about a 1 EPNdB reduction in noise. Increasing only the front rotor blade count to six blades resulted in a noise reduction of about 2 EPNdB. The presence of the pylon resulted in a 1 EPNdB increase in noise. Angle of attack effects showed an increase of 3.5 EPNdB for the tractor configuration and only 1.5 EPNdB for the pusher configuration. Tip speed was found to be the strongest parameter in reducing noise. However, for a given thrust loading, an optimum tip speed is seen. Correlations between measurements and predictions are shown to be in good agreement. Author

A88-16527#
NOISE PREDICTION OF COUNTER ROTATION PROPELLER
T. WATANABE, K. KAWACHI (Tokyo, University, Japan), and Y. NAKAMURA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 8 p. refs
(AIAA PAPER 87-2658)

An analytical study has been conducted in order to make clear the sensitivity of the various design parameters to the sound pressure level. The airloading is calculated by using the newly extended Local Circulation Method. By using the calculated distribution of the airloading as the noise source term, the acoustic field is calculated by integrating it at the retarded time. The results quantitatively indicates that the wake caused by the profile drag of the front rotor becomes the appreciable noise source especially when the distance between the front and rear rotors is small. The wake from the pylon also causes the additional noise, which has the strong azimuthal directivity. The angle of attack of the aircraft leads to increased noise level, which is sensitive to the observer position just under the aircraft. Finally, the sensitivity of the rotor-rotor spacing to the noise level is presented. Author

A88-16530*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACOUSTIC TRANSMISSIBILITY OF ADVANCED TURBOPROP AIRCRAFT WINDOWS
FERDINAND W. GROSVELD (NASA, Langley Research Center; Bionetics Corp., Hampton, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 12 p. refs
(Contract NAS1-16978)
(AIAA PAPER 87-2662)

Advanced turboprop technology allows propeller aircraft to reach cruise speeds comparable to current jet aircraft yet with considerable fuel savings. Due to the higher blade loading and higher tip speed of these propellers, noise levels of up to 150 dB are expected on the outside of the fuselage in the propeller plane. In this study the transmissibility of triple pane windows, designed to provide 69 dB noise transmission loss at the blade propeller frequency of 164 Hz, was experimentally investigated using insertion loss and three-dimensional intensity techniques. A modal analysis on the outer window panes was conducted to determine pane modal frequencies. Coherence and phase relation of outer panes and window frame were established to obtain double/triple wall and lump mass resonance frequencies. Double/triple wall resonances were found to degrade the transmission loss of the two windows. It was shown that, at the blade passage frequency and the first two overtones, the combinations of window plus scratch shield provide less transmission loss than the average transmission loss of the treated fuselage. Strong disagreement was obtained between the experimental transmission loss of this investigation and the theoretical predictions from another study. Author

A88-16533#
AEROACOUSTIC EFFECTS OF BODY BLOCKAGE IN CAVITY FLOW
ROGER S. GATES, CARROLL B. BUTLER (USAF, Armament Laboratory, Eglin AFB, FL), LEONARD L. SHAW (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and RICHARD E. DIX (Calspan Corp., Technology and Analysis Branch, Arnold Air Force Station, TN) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p.
(AIAA PAPER 87-2667)

In order to study the effects of unsteady (dynamic) and steady (static) pressure waves in a cavity at subsonic Mach numbers through transonic Mach numbers, an experimental test program, using a splitter plate and a generic cavity, was conducted. Since most cavities associated with air vehicles house sensors, equipment, or armament, ogive cylinder models were also fabricated and tested inside the cavity to determine their effect on the static and dynamic pressure measurements on the cavity ceiling and walls. The intent of the experiment was to document the effects on steady and unsteady pressures by varying parameters such as the Mach number, cavity dimensions, blockage, and cavity angle of attack. These results will provide engineers with a technology base to aid in the formulation of design requirements and preliminary designs for future air vehicles requiring external cavities. Author

A88-16536#
NUMERICAL SIMULATION OF AERODYNAMIC SOUND RADIATION FROM TWO-DIMENSIONAL WING
SADAO AKISHITA (Mitsubishi Electric Corp., Amagasaki, Japan), KUNIO KUWAHARA, and YOSHIFUMI SHIDA (Tokyo, University, Japan) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 7 p. refs
(AIAA PAPER 87-2672)

This paper describes numerical simulation of random noise radiation from a two-dimensional wing immersed in low subsonic flow. The first model of the flows is a perfectly separated flow around a thin flat plate. A discrete vortex simulation is applied to the flow. The second model is the turbulent boundary layer around a typical airfoil. The high-precision finite-difference method is applied to the latter model. The sound radiation field is calculated from the pressure distribution on the wing surface for both cases. The computed results are compared rather successfully with the experimental data. Author

A88-16537#
A SPECTRAL METHOD FOR THE COMPUTATION OF PROPELLER ACOUSTICS
J. B. H. M. SCHULTEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 12 p. Research sponsored by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs
(AIAA PAPER 87-2674)

In the present study an analytical description of the acoustic field of a propeller in a uniform flow is derived. Instead of applying the usual Ffowcs Williams-Hawkings (1969) version of the acoustic analogy, sources on a surface enclosing the propeller and its adjacent nonlinear flow field are formulated. This approach, which avoids the laborious evaluation of quadrupole source terms, is to be considered as a generalization of the Kirchhoff-Helmholtz theorem of acoustics. By describing the fundamental solution as a spectral Fourier-Bessel decomposition, the resulting sound field is readily given in the appropriate series of harmonic amplitudes. The method is validated by a comparison of numerical results with experimental data of a propeller in an acoustic wind tunnel. A good agreement, both in amplitude and phase, is found between theory and experiment. Author

A88-16540*# Columbia Univ., New York, N.Y.
STRUCTURE-BORNE NOISE TRANSMISSION IN STIFFENED STRUCTURES
RIMAS VAICAITIS (Columbia University, New York) and CONSTANTINOS S. LYRINTZIS (San Diego State University, CA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 8 p. refs
(Contract NAG1-541)
(AIAA PAPER 87-2679)

The structure-borne noise transmission of stiffened and interconnected structures under random loads is presented. The method is based on the transfer matrix for the structural response and on the modal decomposition for the interior acoustic field. The acoustic enclosure is taken to be rectangular in shape of which portion of the boundaries are elastic while the remaining surface is acoustically rigid. Numerical results are presented for several acousto-structural problems. Author

A88-16541*# Southwest Research Inst., San Antonio, Tex.
STRUCTURE-BORNE NOISE CONTROL FOR PROPELLER AIRCRAFT
JAMES F. UNRUH (Southwest Research Institute, San Antonio, TX) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 8 p. refs
(Contract NAS1-17921)
(AIAA PAPER 87-2680)

A laboratory test apparatus was developed which would allow the study and development of propeller wake/vortex-induced structure-borne interior noise control measures. Various methods of wing structural modification, including blocking masses, surface damping treatments, and tuned mechanical absorbers, were evaluated relative to reduced interior noise levels. Inboard wing fuel was found to act as an effective blocking mass. Wing panel add-on damping treatment in the form of a single, constrained layer was not an effective control measure, except in the area of the propeller wake. However, highly damped, tuned mechanical absorbers were found to be the most efficient structure-borne noise (SBN) control measure. Author

A88-16548#
NOZZLE GEOMETRY EFFECTS ON SUPERSONIC JET INTERACTION
R. W. WLEZIEN (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. refs
(AIAA PAPER 87-2694)

The coupled interaction of jets from two nominally identical convergent/divergent nozzles is examined as a function of nozzle spacing. The screech modes of two coupled jets correspond to those observed for single plumes, but the modal amplitudes are strongly dependent on nozzle spacing. For closely-spaced nozzles, coupling occurs at low jet Mach numbers and is suppressed at high Mach numbers. The converse is true for large spacing. The amplitude of the coupled jets is independent of the nozzle design Mach number, unlike the screech amplitudes of isolated plumes, which decrease near the design point. Interference between the plumes and the relative phasing of the acoustic sources are proposed as mechanisms for the geometry dependence of the jet coupling. Author

A88-16550*# Florida State Univ., Tallahassee.
ANALYSIS OF TWIN SUPERSONIC PLUME RESONANCE
CHRISTOPHER K. W. TAM (Florida State University, Tallahassee) and J. M. SEINER (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 11 p. refs
(Contract NAG1-421)
(AIAA PAPER 87-2695)

Recent experiments conducted at NASA Langley show that twin supersonic jets separating by a distance of approximately two nozzle diameters (center to center) exhibit resonant oscillations under a wide range of operating conditions. In this paper the mechanism responsible for the synchronized resonant oscillations

is investigated. A vortex sheet jet model is used in the analysis. The model shows that kinematically two modes of twin jet resonance can occur. One mode involves flapping motion of both jets symmetric with respect to the mid-plane separating the two jets. The other mode involves antisymmetric flapping motion. The symmetric mode is consistent with experimental observations. The vortex sheet jet model is, however, unable to provide quantitative estimates of the shift in screech frequency (as compared to a single jet) due to the resonance phenomenon. The reason for this is discussed. Possible improvement of the model and directions for future work are indicated. Author

A88-16551#
A REFLECTION MECHANISM FOR AFT FAN TONE NOISE FROM TURBOFAN ENGINES
D. A. TOPOL, S. C. HOLHUBNER, and D. C. MATHEWS (Pratt and Whitney, East Hartford, CT) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 8 p. refs
(AIAA PAPER 87-2699)

A fan tone noise mechanism is proposed which results from reflections from the fan of forward propagating rotor wake/fan exit guide vane interaction tone noise. These fan noise tones are often more dominant out of the rear than out of the front of an engine. To simulate this effect a simple qualitative prediction model was formulated and a scaled model test program was conducted. Results from each of these investigations are compared with each other and with full-scale engine data. These comparisons substantiate the potential importance of this mechanism. Further support is provided by mode measurement data from full-scale testing. This study concluded that for certain vane/blade ratios and tip Mach numbers the contribution of the reflection noise mechanism is significant. Author

A88-16552#
DETECTION OF FAN ACOUSTIC MODE
YOSHIYA NAKAMURA and KOUSUKE ISOMURA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 12 p. refs
(AIAA PAPER 87-2700)

The devices to detect fan acoustic mode, both in the duct and in the radiated field were developed, and their capability to define noise source was demonstrated. The acoustic mode of double stream test fan was investigated using these devices, originally intended to study the relation between outlet guide vane/strut configuration, such as vane number or cyclic staggering. However, it was shown that the inlet disturbance due to inflow control device frame caused the interaction noise with fan blade, which masked the fan original noise. Author

A88-16553#
DUCTED FAN NOISE PROPAGATION IN NON-UNIFORM FLOW. I - TEST BACKGROUND AND SIMPLIFIED MODEL
T. G. SOFRIN and D. E. CICON (Pratt and Whitney, East Hartford, CT) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 12 p. refs
(AIAA PAPER 87-2701)

Several examples are given of anomalous fan noise modal spectra, determined from in-duct array measurements. These consistent distorted spectra led to an investigation into their origin, which came to focus upon non-uniform axial flow as a common basic cause. Supporting data and the results of a simplified analytic treatment led to a procedure for predicting the effects of flow non-uniformity and to a method for reducing its influence in estimating the dominant sources of fan noise from array measurements. Author

A88-16559*# Purdue Univ., West Lafayette, Ind.
ACTIVE CONTROL OF SOUND FIELDS IN ELASTIC CYLINDERS BY MULTI-CONTROL FORCES
J. D. JONES (Purdue University, West Lafayette, IN) and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. refs
(Contract NAG1-390)
(AIAA PAPER 87-2707)

An unstiffened cylindrical model was used to study the control of sound transmission into aircraft cabins by the use of multi-control forces applied directly to the cylinder wall. External acoustic monopoles were located on each side of the cylinder to approximate the propeller noise source. This allowed the study of a dual control system utilizing multi-control forces in conjunction with synchrophasing of the twin acoustic monopole sources. For acoustic resonant conditions within the cavity, a spatially averaged noise reduction of approximately 30 dB was achieved using the active control system for both in-phase and out-of-phase monopoles; however, effective reduction of the sound field was dependent upon judiciously positioning the control forces for optimal control of the sound field. Author

A88-16563#
AN EXPERIMENTAL INVESTIGATION OF THE COHERENT STRUCTURE IN AN INCOMPRESSIBLE JET
GERALD L. MORRISON, GARY B. TATTERSON (Texas A & M University, College Station), and SAIED EMAMI AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. refs
(AIAA PAPER 87-2715)

An experimental investigation of an incompressible Mach 0.15 free jet under the influence of acoustic disturbances at a Strouhal number of 0.50 was performed in order to determine the overall turbulence characteristics and the contributions of the coherent structure to the turbulent flow field. Maximum turbulence levels of 12 percent for the axial and 11 percent for the radial turbulence intensities were found based upon the jet exit velocity. The axial and radial ensemble averaged turbulence intensities were shown to be maximized before the end of the potential core and to decay rapidly past the end of the potential core. Reynolds stress contours and mean velocity distributions were also obtained, yielding the contours of the kinematic eddy viscosity. R.R.

A88-16564#
MEASUREMENT ON ACOUSTIC SOURCE-STRENGTH DISTRIBUTION OF COAXIAL JETS
Y. NAKAZONO (Kyushu Tokai University, Kumamoto, Japan) and S. KOTAKE (Tokyo, University, Japan) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 7 p. refs
(AIAA PAPER 87-2716)

The distribution of acoustic source strength in coaxial jets has been studied experimentally by the reflector-mirror microphone method. The acoustic sources are most intensively distributed in the mixing regions between the inner and outer jets. The source strength in this region is greatly dominated by the relative velocity of the inner and outer jets, taking the minimum at the velocity ratio of about 0.5. The area ratio and the relative position of the nozzles are changed to study their effects on the source distribution. Increase in the area ratio shifts the acoustic source downstream in the outer jet without any change in the inner jet. Extending the inner jet nozzle moves the noise source in the inner jet to the downstream without any change of the outer jet, while extending the outer nozzle shifts wholly the noise source distribution downstream. Author

A88-16565*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRUISE NOISE OF THE 2/9 SCALE MODEL OF THE LARGE-SCALE ADVANCED PROPFAN (LAP) PROPELLER, SR-7A
JAMES H. DITTMAR (NASA, Lewis Research Center, Cleveland, OH) and DAVID B. STANG (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 18 p. Previously announced in STAR as N87-28398. refs
(AIAA PAPER 87-2717)

Noise data on the Large-scale Advanced Propfan (LAP) propeller model SR-7A were taken in the NASA Lewis Research Center 8 x 6 foot Wind Tunnel. The maximum blade passing tone noise first rises with increasing helical tip Mach number to a peak level, then remains the same or decreases from its peak level when going to higher helical tip Mach numbers. This trend was observed for operation at both constant advance ratio and approximately equal thrust. This noise reduction or, leveling out at high helical tip Mach numbers, points to the use of higher propeller tip speeds as a possible method to limit airplane cabin noise while maintaining high flight speed and efficiency. Projections of the tunnel model data are made to the full scale LAP propeller mounted on the test bed aircraft and compared with predictions. The prediction method is found to be somewhat conservative in that it slightly overpredicts the projected model data at the peak. Author

A88-16566*# PRC Kentron, Inc., Hampton, Va.
ADDED NOISE DUE TO THE EFFECT OF AN UPSTREAM WAKE ON A PROPELLER
M. A. TAKALLU, P. L. SPENCE (PRC Kentron, Inc., Hampton, VA), and P. J. W. BLOCK (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. refs
(AIAA PAPER 87-2720)

An analytical/computational study has been conducted to predict the effect of an upstream wing or pylon on the noise of an operating propeller. The wing trailing edge was placed at variable distances (0.1 and 0.3 chord) upstream of a scaled model propeller (SR-2). The wake was modeled using a similarity formulation. The instantaneous pressure distribution on the propeller blades during the passage through the wake was formulated in terms of a time-dependent variation of each blade section's angle of attack and in terms of the shed vortices from the blade trailing edge. It was found that the final expressions for the unsteady loads considerably altered the radiated noise pattern. Predicted noise for various observer positions, rotational speeds, and propeller/pylon distances were computed and are presented in terms of the pressure time history, harmonics of the Fourier analysis, and overall sound pressure levels (OASPL). The addition of the tangential stress due to skin friction was found to have a damping effect on the acoustic pressure time history and the resulting spectrum of the generated noise. It is shown that the positioning of a pylon upstream of a propeller indeed increases the overall noise. Author

A88-16569#
FLOW-INDUCED NOISE FROM WIND TUNNEL TURBULENCE REDUCTION SCREENS
RICHARD M. ALLEN, RICHARD R. GIBBS (Boeing Commercial Airplane Co., Seattle, WA), and PATRICK J. F. CLARK (DSMA International, Inc., Toronto, Canada) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 6 p. refs
(AIAA PAPER 87-2728)

Boeing is acquiring a new Low Speed Aeroacoustic Facility to simulate low speed flight conditions by adding a free jet to an existing anechoic chamber. The primary facility characteristics will be high flow quality and low background noise levels in the open jet test section. During the design phase, it was recognized that noise generated by flow through the turbulence reduction screens could intrude on the test section noise floor. Since no published information could be found on flow noise in screens, experiments were conducted to measure flow noise for a wide variety of screen sizes and airflow velocities. Data analysis, using multiple regression, produced a screen noise prediction equation for overall sound power as a function of flow velocity, screen wire diameter, number of screens, and screen cross-sectional area. This prediction should be useful for wind tunnel design when low test section sound levels are required. Author

A88-16570#
A STUDY OF SOME FACTORS AFFECTING THE AEROACOUSTIC PERFORMANCE OF A DUCTED CONTRA-ROTATING AXIAL FLOW FAN STAGE
P. B. SHARMA, D. S. PUNDHIR, and K. K. CHAUDHRY (Indian Institute of Technology, New Dehli, India) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 8 p. Research supported by the Aero Research and Development Board of India. refs
(AIAA PAPER 87-2730)

The paper reports the results of an experimental investigation into the aeroacoustic performance of a ducted contra-rotating axial flow fan stage having a hub-tip ratio of 0.66. Aerodynamic superiority of a contra-stage is examined from the point of view of higher pressure rise, increased through flow and rotating stall suppression. Measurements of sound pressure levels and real time analysis of the noise signals is reported for different speed combinations for clean and distorted inlet flow for two axial gaps between the contra-rotors. The effect of pitch chord ratio and axial gap between the rotors on the aeroacoustic performance is discussed. The study reveals that the axial gap between the rotors significantly affects the aeroacoustic performance of a contra-fan stage. Author

A88-16571*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AEROACOUSTICS OF SUBSONIC TURBULENT SHEAR FLOWS
MARVIN E. GOLDSTEIN (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. Previously announced in STAR as N87-26615. refs
(AIAA PAPER 87-2731)

Sound generation in turbulent shear flows is examined. The emphasis is on simultaneous calculation of the turbulent flow along with the resulting sound generation rather than the alternative acoustic analogy approach. The first part of the paper is concerned with solid surface interaction. The second part concentrates on the sound generated by turbulence interacting with itself. Author

A88-16576#
ACOUSTIC AND AERODYNAMIC CHARACTERISTICS OF PERFOLIN, THE LINEAR PERFORATED PLATE ACOUSTIC LINER
T. ZANDBERGEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Emmeloord, Netherlands) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 14 p. refs
(AIAA PAPER 87-2740)

Test results on a linear perforated acoustic liner material named Perfolin, consisting of a honeycomb structure with a microporous facing sheet containing horn shaped orifices, are presented. The impedance of the Perfolin liners is shown to have low sensitivity to flow and sound pressure level. Its surface is aerodynamically smooth, and its low mass reactance gives it a broad frequency band of absorption. The acoustic resistance of Perfolin is found to be independent of frequency. Further improvement of Perfolin face sheet properties should be possible by promoting laminar viscous dissipatation while reducing the generation of vorticity and separation areas. R.R.

A88-16578*# Missouri Univ., Rolla.
A MODEL OF THE WALL BOUNDARY LAYER FOR DUCTED PROPELLERS
WALTER EVERSMAN (Missouri-Rolla, University, Rolla) and WILLI MOEHRING (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. refs
(Contract NAG3-178)
(AIAA PAPER 87-2742)

The objective of the present study is to include a representation of a wall boundary layer in an existing finite element model of the propeller in the wind tunnel environment. The major consideration is that the new formulation should introduce only modest alterations in the numerical model and should still be capable of producing economical predictions of the radiated acoustic field. This is accomplished by using a stepped approximation in which the velocity profile is piecewise constant in layers. In the limit of infinitesimally thin layers, the velocity profile of the stepped approximation coincides with that of the continuous profile. The approach described here could also be useful in modeling the boundary layer in other duct applications, particularly in the computation of the radiated acoustic field for sources contained in a duct. V.L.

A88-16579#
A SOURCE LOCALIZATION TECHNIQUE FOR HELICOPTER ROTOR NOISE
D. BLACODON, M. CAPLOT, and G. ELIAS (ONERA, Chatillon-sous-Bagneux, France) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 10 p. refs
(AIAA PAPER 87-2743)

A multimicrophone array technique for the localization of helicopter rotor impulsive noise sources is developed and applied here to the acoustic radiation of blade-vortex interaction. To isolate correctly the phenomenon, the analysis is made in the time domain rather than in the frequency one. Two kinds of array processing are presented: a linear beam forming and a multiplicative processing. For the case of a simple source, both techniques give good results. But in the case of multiple-point sources, only the second processing is accurate; the linear beam forming cannot detect two sources which are closely spaced. Comparisons of computed simulations with an anechoic chamber experiment show a very good agreement. Finally, the multiplicative processing is applied to a helicopter rotor noise test in the CEPRA 19 anechoic wind tunnel. In this experiment, the rotor blades were equipped with blade pressure transducers which give the blade-vortex interaction loci. Comparison, for one interaction, between the array technique and the measured values presents a good agreement, when the flow effects (i.e., convection and refraction) are taken into account. Author

A88-16580*# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
ROTOR BLADE-VORTEX INTERACTION IMPULSIVE NOISE SOURCE IDENTIFICATION AND CORRELATION WITH ROTOR WAKE PREDICTIONS
W. R. SPLETTSTOESSER, K. J. SCHULTZ (DFVLR, Brunswick, Federal Republic of Germany), and RUTH M. MARTIN (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 23 p. refs
(AIAA PAPER 87-2744)

An acoustic source localization scheme applicable to noncompact moving sources is developed and applied to the blade-vortex interaction (BVI) noise data of a 40-percent scale BO-105 model rotor. A generalized rotor wake code is employed to predict possible VBI locations on the rotor disk and is found quite useful in interpreting the acoustic localization results. The highly varying directivity patterns of different BVI impulses generated at the same test condition are explained by both the localization results and predicted tip vortex trajectories. The effects of rotor tip-path-plane angle and advance ratio on the BVI source positions is studied. Decreasing tip-path-plane angle (at constant advance ratio) moves the general interaction region upwind on the rotor disk, significantly changing the interaction geometry. Increasing advance ratio (at constant tip-path-plane angle) shifts the general source region downwind on the rotor disk with the increased convection of the vortices until about 60 deg azimuth, where the BVI sources appear to become acoustically less effective. The region of strongest BVI sources lies between 60 and 70 deg azimuth and 80 and 90 percent radius for the moderate range of advance ratios studied. Author

A88-16581*# Florida Atlantic Univ., Boca Raton.
THE PREDICTION OF HELICOPTER TAIL ROTOR NOISE ON THE FLIGHT PATH
STEWART A. L. GLEGG (Florida Atlantic University, Boca Raton) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 7 p.
(Contract NAG1-715)
(AIAA PAPER 87-2747)

Experimental measurements on a model scale helicopter in a wind tunnel have shown that the levels radiated in the direction of flight are strongly dependent on the fuselage angle to the mean flow. Here a theoretical model is derived to explain these measurements using unsteady thickness noise as the principle source mechanism. The model includes the effect of fuselage wake turbulence which is convected through only the lower sector of the rotor disk. This causes spectral peaks which do not occur at blade passing frequencies, but rather at frequencies associated with convected flow inhomogeneities. The results are compared with measurements and show good agreement over a range of fuselage angles and mean flow speeds. Author

A88-16582*# Textron Bell Helicopter, Fort Worth, Tex.
PREDICTION OF BLADE-VORTEX INTERACTION NOISE USING MEASURED BLADE PRESSURES
MAHENDRA C. JOSHI, SANDY R. LIU (Bell Helicopter Textron, Inc., Fort Worth, TX), and DONALD A. BOXWELL (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Aeroacoustics Conference, 11th, Sunnyvale, CA, Oct. 19-21, 1987. 11 p. refs
(Contract NAS1-17148)
(AIAA PAPER 87-2749)

In the study reported here, blade-vortex interaction noise was predicted using a simplified model of blade pressures measured on a one-seventh scale model AH-1/OLS main rotor. The methods used for the acoustic prediction are based on the acoustic analogy and have been developed by Nakamura (1981) and by Brentner, Nystrom, and Farassat (referred to as the WOPWOP method). The waveforms predicted by the two methods are in good agreement with each other and with the measurements in terms of the number of pulses, the pulse widths, and the separation times between the pulses. The peak amplitude of the dominant pulse may, however, be underpredicted by up to 40 percent, depending on flight conditions. Ways of improving the accuracy of the prediction methods are suggested. V.L.

N88-12352*# Calspan Advanced Technology Center, Buffalo, N.Y. Physical Sciences Dept.
A HYBRID NUMERICAL TECHNIQUE FOR PREDICTING THE AERODYNAMIC AND ACOUSTIC FIELDS OF ADVANCED TURBOPROPS Final Report
G. F. HOMICZ and J. R. MOSELLE Apr. 1985 71 p
(Contract NAS3-23699)
(NASA-CR-174926; NAS 1.26:174926; CALSPAN-7157-A-1)
Avail: NTIS HC A04/MF A01 CSCL 20A

A hybrid numerical procedure is presented for the prediction of the aerodynamic and acoustic performance of advanced turboprops. A hybrid scheme is proposed which in principle leads to a consistent simultaneous prediction of both fields. In the inner flow a finite difference method, the Approximate-Factorization Alternating-Direction-Implicit (ADI) scheme, is used to solve the nonlinear Euler equations. In the outer flow the linearized acoustic equations are solved via a Boundary-Integral Equation (BIE) method. The two solutions are iteratively matched across a fictitious interface in the flow so as to maintain continuity. At convergence

the resulting aerodynamic load prediction will automatically satisfy the appropriate free-field boundary conditions at the edge of the finite difference grid, while the acoustic predictions will reflect the back-reaction of the radiated field on the magnitude of the loading source terms, as well as refractive effects in the inner flow. The equations and logic needed to match the two solutions are developed and the computer program implementing the procedure is described. Unfortunately, no converged solutions were obtained, due to unexpectedly large running times. The reasons for this are discussed and several means to alleviate the situation are suggested. Author

N88-13002*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MEASUREMENT OF VELOCITY AND VORTICITY FIELDS IN THE WAKE OF AN AIRFOIL IN PERIODIC PITCHING MOTION
EARL R. BOOTH, JR. Dec. 1987 31 p
(NASA-TP-2780; L-16339; NAS 1.60:2780) Avail: NTIS HC A03/MF A01 CSCL 20A

The velocity field created by the wake of an airfoil undergoing a prescribed pitching motion was sampled using hot wire anemometry. Data analysis methods concerning resolution of velocity components from cross wire data, computation of vorticity from velocity time history data, and calculation of vortex circulation from vorticity field data are discussed. These data analysis methods are applied to a flow field relevant to a two dimensional blade-vortex interaction study. Velocity time history data were differentiated to yield vorticity field data which are used to characterize the wake of the pitching airfoil. Measurement of vortex strength in sinusoidal and nonsinusoidal wakes show vortices in the sinusoidal wake have stronger circulation and more concentrated vorticity distributions than the tailored nonsinusoidal wake. Author

N88-13003*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RESULTS OF THE 1986 NASA/FAA/DFVLR MAIN ROTOR TEST ENTRY IN THE GERMAN-DUTCH WIND TUNNEL (DNW)
THOMAS F. BROOKS and RUTH M. MARTIN Oct. 1987 24 p
(NASA-TM-100507; NAS 1.15:100507) Avail: NTIS HC A03/MF A01 CSCL 20A

An acoustics test of a 40%-scale MBB BO-105 helicopter main rotor was conducted in the Deutsch-Niederlandischer Windkanal (DNW). The research, directed by NASA Langley Research Center, concentrated on the generation and radiation of broadband noise and impulsive blade-vortex interaction (BVI) noise over ranges of pertinent rotor operational envelopes. Both the broadband and BVI experimental phases are reviewed, along with highlights of major technical results. For the broadband portion, significant advancement is the demonstration of the accuracy of prediction methods being developed for broadband self noise, due to boundary layer turbulence. Another key result is the discovery of rotor blade-wake interaction (BWI) as an important contributor to mid frequency noise. Also the DNW data are used to determine for full scale helicopters the relative importance of the different discrete and broadband noise sources. For the BVI test portion, a comprehensive data base documents the BVI impulsive noise character and directionality as functions of rotor flight conditions. The directional mapping of BVI noise emitted from the advancing side as well as the retreating side of the rotor constitutes a major advancement in the understanding of this dominant discrete mechanism. Author

N88-13005*# Duke Univ., Durham, N. C. Dept. of Mechanical Engineering and Materials Science.
AIRCRAFT INTERIOR NOISE REDUCTION BY ALTERNATE RESONANCE TUNING Progress Report
JAMES A. GOTTWALD and DONALD B. BLISS Dec. 1987 14 p
(Contract NAG1-722)
(NASA-CR-181530; NAS 1.26:181530) Avail: NTIS HC A03/MF A01 CSCL 20A

Model problem development and analysis continues with the Alternate Resonance Tuning concept. Various topics are presently at different stages of completion and are described. These topics included optimization of panel mass ratios, panel computer code verification and agreement with experimental data, and flexible frame modeling. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A88-14256#
AIRCRAFT DESIGN EDUCATION AT THE ROYAL MILITARY COLLEGE OF SCIENCE SHRIVENHAM (CIT) AND KINGSTON POLYTECHNIC
RAY WHITFORD (Royal Military College of Science, Shrivenham, England) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 10 p. refs
(AIAA PAPER 87-2867)

This paper briefly outlines the layout of typical UK Aeronautical Engineering degree courses and shows how a group design project is used as an integrator of core-curriculum subjects. The objectives, organization and management of final year undergraduate group projects in aircraft design at two UK colleges are described. Emphasis is placed on achieving realism in the feasibility studies carried out by small teams with projects selected to reflect current or future needs for aircraft. Details of the design activities, industry/military participation, useful references and the benefits of CAD are discussed. Fifteen years' experience including a year spent at a U.S. university together with feedback from industry has shown the great value of such projects. Author

A88-14257#
AIRCRAFT DESIGN EDUCATION IN CHILE
FERNANDO F. MUJICA (Academia Politecnica Aeronautica, Chile) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 8 p.
(AIAA PAPER 87-2869)

The only institute to graduate aeronautical engineers in Chile is the Academia Politecnica Aeronautica of the Chilean Air Force. A very important part of the six-year curriculum is the aircraft design project in the final year. In this paper, it is shown how the aeronautical engineer curriculum leads the students to the final project of Aircraft Design, which is a conceptual design of an aircraft that satisfies a current or future operational requirement of the Chilean Air Force. Finally, the general procedure of the aircraft design course is presented, and projects developed by the students during recent years are shown, including a basic training, an advanced training/attack, and a tactical transport aircraft. Author

A88-14286#
PROGRAM MANAGEMENT OF THE F-16 PROGRAM
F. A. CURTIS, JR. (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 12 p.
(AIAA PAPER 87-2962)

The program management team that conceived, designed, developed, and is producing (with multinational coproducers) the F-16 multirole combat fighter was established to effectively manage the system in the various program phases. The overall major program management challenge is to maintain quality, schedule, and low cost in the program environment of continually changing, simultaneous, major program phases: i.e. (1) multiple major configuration production deliveries, (2) maturation and upgrade of the operational fleet, and (3) evolutionary development and

transition to high-rate production of new models. The scope and complexity of the challenge to the F-16 program management team plus key programmatic lessons learned are directly related to some of the call for paper topics related to technical management approaches/techniques. Keys to the success of the program and the management thereof are: (1) the effective Air Force, contractor, subcontractor, and coproducer team relationship, (2) a prime contractor management team tailored to the program, (3) timely/augmented feedback from the using commands, (4) attention to cost and supportability from the onset, (5) lack of major technical problems, and (6) continual enhancement of product integrity and combat capability for both new production and fleet retrofit. Author

A88-14360
TRANSPORT AIRCRAFT SAFETY - AN AVIATION COMMUNITY COMMITMENT
RICHARD W. TAYLOR (Boeing Co., Seattle, WA) SAE, Aerospace Vehicle Conference, Washington, DC, June 8-10, 1987. 11 p.
(SAE PAPER 871328)

The historical record is evaluated in a discussion of the extent to which product liability litigation detracts from, rather than enhances, the safe design and manufacture of transport aircraft. Product failure is noted to have been the cause of less than 18 percent of transport aircraft accidents. Attention is given to the goals of safe aircraft design, manufacture, operation, maintenance, and operating environments. Specific problems emerging in the current accident litigation system are discussed with a view to the formulation of a 'no-fault' accident claim system that can be instituted as a legislative solution to the contemporary impasse. O.C.

A88-14361
THE IMPACT OF PRODUCT LIABILITY LITIGATION ON THE AVIATION COMMUNITY - A GENERAL AVIATION AIRCRAFT MANUFACTURER'S VIEW
MAX E. BLECK and BRUCE E. PETERMAN (Cessna Aircraft Co., Wichita, KS) SAE, Aerospace Vehicle Conference, Washington, DC, June 8-10, 1987. 8 p.
(SAE PAPER 871329)

The General Aviation Manufacturers Association is a major proponent of legislation to reform current tort law procedures concerning general aviation product liability, which vary from state to state; the aim of these efforts is to replace such state liability statutes with a uniform federal standard for manufacturers. The present discussion contrasts manufacturers' emphasis of safety practices in view of FAA regulations and the general declining trend for fatal aircraft accidents, on the one hand, with the impact of product liability litigation, on the other. O.C.

A88-14362
THE IMPACT OF PRODUCT LIABILITY ON AVIATION DEVELOPMENT
FREDERICK B. SONTAG (General Aviation Manufacturer's Association, Inc., Washington, DC; Unison Industries, Inc., Rockford, IL) SAE, Aerospace Vehicle Conference, Washington, DC, June 8-10, 1987. 6 p.
(SAE PAPER 871330)

The recent history of product liability is noted to have been characterized by legal maneuvers aimed solely at the establishment of a source for the paying of damages, irrespective of true fault. These maneuvers threaten to curtail the important element of innovation in aviation development. The situation is frequently so aggravated that a number of manufacturers have either foregone liability insurance because of its excessive cost or been unable to find coverage at any price. A number of companies have lost valuable sources of component supply due to their fear of involvement in product liability proceedings. O.C.

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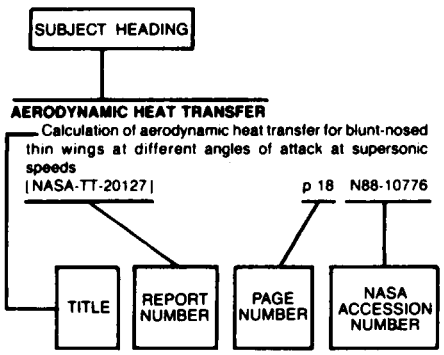

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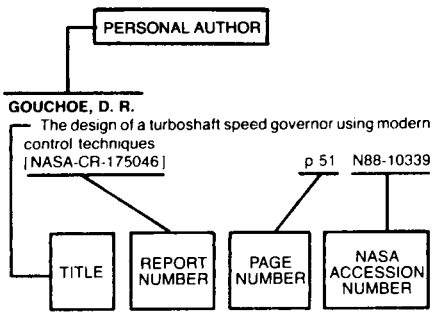

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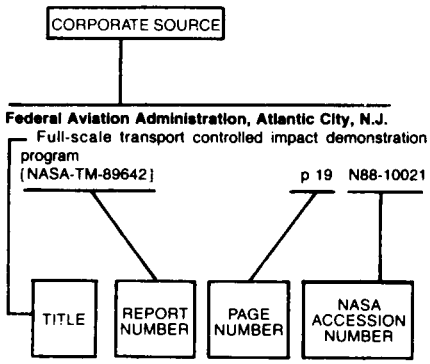

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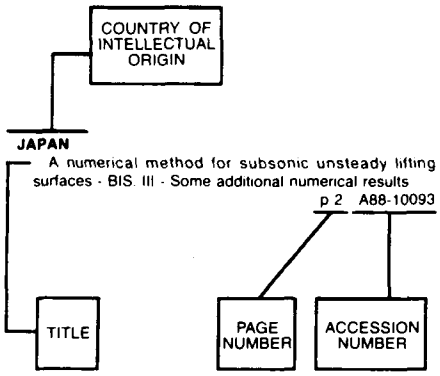

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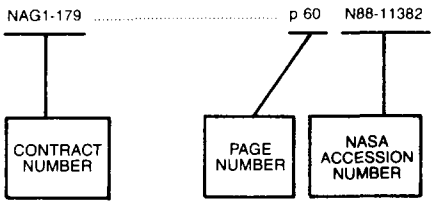

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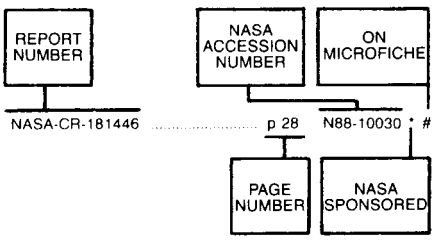

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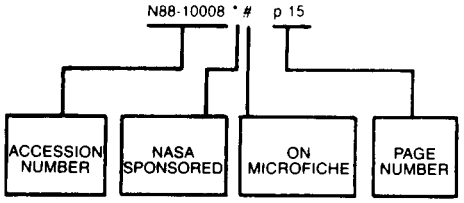

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